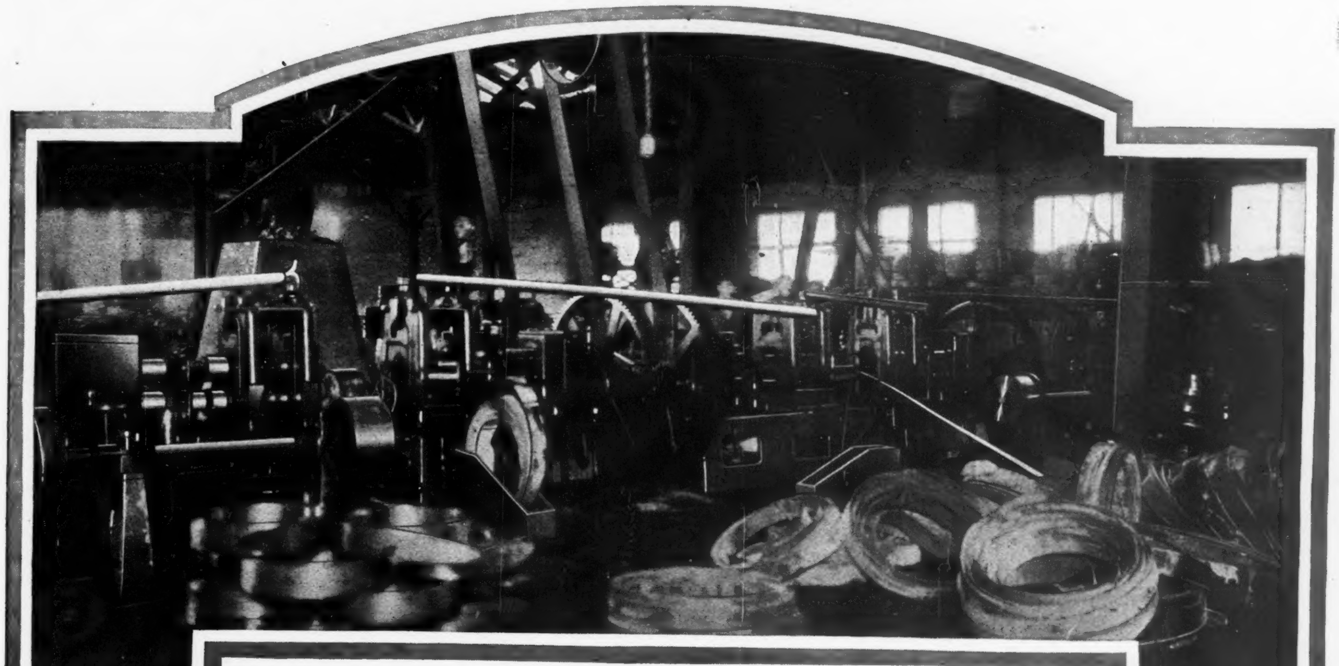
VOLUME 23 NUMBER 1 Engineering Library SEPTEMBER, 1916 $2.00 A YEAR 20 CENTS A COPY

THE LARGEST MECHANICAL CIRCULATION IN THE WORLD

MACHINERY

PUBLICATION OFFICES 140-148 LAFAYETTE STREET, CORNER HOWARD, NEW YORK

ADVERTISERS INDEX, PAGE 302—PRODUCT INDEX 288-300



Cold-Rolling Strip Steel

by Edward K. Hammond

As its name implies, cold-rolled steel is produced by rolling the metal cold, and two noteworthy advantages are obtained in this way: First, the tendency to oxidize and form a scale, which cannot be avoided when steel is rolled hot, is entirely overcome by cold-rolling, so that the steel may be given what is known as a "bright" finish. Second, the avoidance of oxidation enables the gage of the steel to be held within very close limits; on the thicker gages the limit of accuracy is within 0.0015 inch, while the thinnest gages are guaranteed to be within 0.00025 inch of the specified thickness. Also, the process of cold-rolling enables steel to be rolled true to gage as thin as 0.003 inch, which would not be practicable with hot metal because of uneven heating and expansion.

BELIEF in the possibility of keeping trade secrets has been more strongly relied upon in conducting various metallurgical operations than has been the case in many other industries. Progressive manufacturers of the present generation have generally acknowledged the fact that it is exceedingly difficult, if not impossible, to hold a trade secret inviolate; and recognizing this fact, they have come to place more reliance upon perfecting every detail of each manufacturing operation, instead of expecting to attain or hold commercial supremacy by the possession of secret methods with which competitors are unfamiliar. Reliance in trade secrets has probably been responsible for the lack of published information concerning methods employed in the manufacture of cold-rolled steel; at least very little information has been published on this subject, and, as a result, the following article which describes the methods employed in the production of cold-rolled strip steel at the plant of the Schwartz-Herrmann Steel Co., Floral Park, Somerville, N. J., should prove of material interest to readers of MACHINERY.

Cold-rolled steel possesses several advantages which cannot be secured with metal that is rolled hot. Most noteworthy of these is the fact that rolling the metal cold enables it to be given a so-called "bright" finish; that is to say, there is no oxide or stains on its surface. Where the steel is rolled hot, this advantage cannot be obtained, because hot metal is easily attacked by oxygen of the air that results in forming the well-known scale with which heated metal is covered. Those who have had experience in the working of sheet steel know that this oxide scale is exceedingly hard, and that it exerts a very harmful effect on the dies. For this reason, cold-rolled steel is in demand for use in the manufacture of various pressed steel products. In addition to the advantage secured through the absence of scale in working cold-rolled steel under the punch press, the possibility of rolling steel without forming any scale has another important advantage. Sheet metal produced in this way can be rolled very thin—the limit being about 0.003 inch—and the thickness can be held within close limits. It will be evident that this would be utterly impossible if the metal were at a red heat, because the production of scale would not only cause considerable variation in the gage of the metal, but with extremely thin sheets it would actually result in its complete destruction.

Raw Materials of the Industry

Mills engaged in the manufacture of cold-rolled steel secure their raw material in the form of hot-rolled ribbon stock of thickness somewhat greater than that of the cold-rolled steel which is to be produced. The treatment of this material in early stages of the process will differ according to its carbon content. With steel which does not contain over 0.30 per cent of carbon, it is unnecessary to conduct a preliminary annealing process; but steel with more than 30 points of carbon must be annealed before the rolling

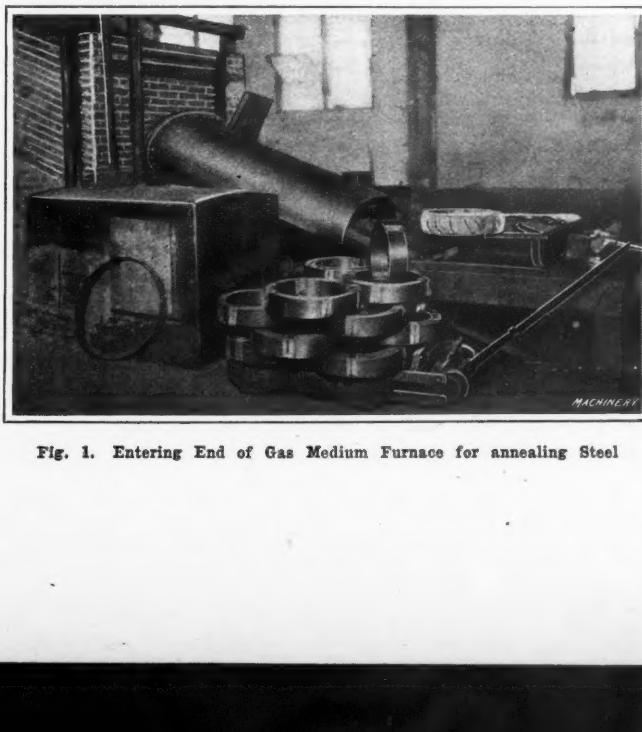


Fig. 1. Entering End of Gas Medium Furnace for annealing Steel

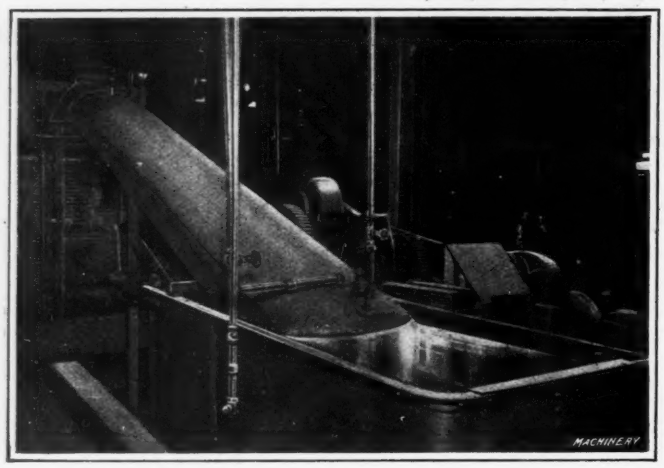


Fig. 2. Delivery End of Gas Medium Furnace—note Arrangement of Water Seal

can be started. For the purpose of describing the method of manufacturing cold-rolled steel in this article, we will assume that the mill is working on high-carbon steel which requires a preliminary annealing in order to make it soft enough to be rolled advantageously. Three forms of annealing furnaces are employed for this purpose, and the selection of the particular form of furnace to use will depend upon the analysis of the metal. These furnaces are known as the "gas medium" annealing furnace, the "pot" annealing furnace, and the "muffle" annealing furnace. In the muffle furnace the metal is heated in contact with the air, so that an oxide scale is formed over it, while in the pot furnace and the gas medium furnace the metal is protected from the air, so that all tendency to oxidize is avoided. One of the latter types of furnaces is generally used, but the muffle or "scale" annealing furnace is employed where the stock which is to be converted into cold-rolled steel

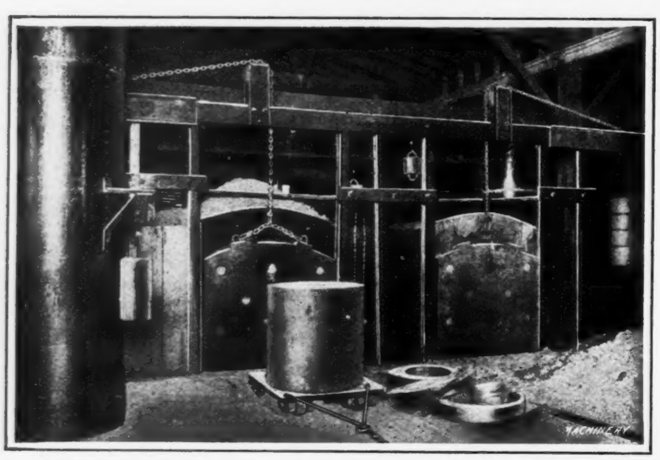


Fig. 3. Pot Annealing Furnace, showing Pot just drawn out

has been treated in such a way that its surface has become decarbonized. With such material the production of a scale on the surface of the steel is an advantage, because it removes that part of the metal from which the carbon has been withdrawn. This will be referred to in more detail in connection with the description of the pickling process. In all types of furnaces, the temperature employed varies from 1150–1300 degrees F., according to the carbon content of the steel.

Gas Medium Furnace

The process of annealing steel in the gas medium furnace consists primarily of raising its temperature to the required degree and then allowing the metal to cool slowly. This result is accomplished by placing the coils of ribbon stock on a chain conveyor which carries them through the furnace. The conveyor is driven by an electric motor which transmits power through a train of high reduction gearing, so that it takes about six hours for the steel to pass through the furnace. The conveyor carries the steel through a steel tube surrounded with firebrick in the heating furnace, which is built around the portion of this tube in which the heating of the steel is conducted. The furnace is of simple construction, consisting of a checker work of firebrick which is kept at a red heat by the combustion of producer gas; and in order that the furnace may operate at the maximum economy, the draft in this furnace is arranged in such a way that the gas and hot products of combustion pass through the furnace in a winding course which has somewhat the form of the letter S. In this way the gases leave the furnace at a relatively low temperature, having given up most of their heat to the brick checker work.

As the essential difference between hot-rolled and cold-rolled steel is that the latter is entirely free from oxide scale—and

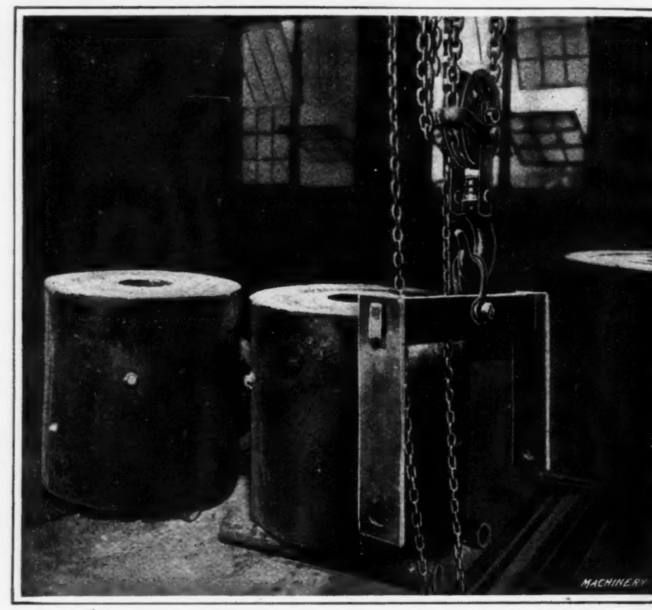


Fig. 4. Pots of Steel and Special Hoist for lifting them—note Central Hole in Pots to allow Heat to enter from All Sides

as the method of manufacture is carried on with the view of eliminating scale—it will be evident that in the preliminary treatment of the metal it is desirable to avoid scaling as far as possible. Such being the case, the annealing must be conducted in an atmosphere which is free of oxygen, and this result is obtained by having the tube in the annealing furnace filled with produced gas. This gas enters the tube at one end and passes through to the opposite end, where there is a burner that provides for consuming the gas as it leaves the tube. It will be seen from Fig. 1 that the conveyor tube rises at a gradual angle until it has passed through the furnace, after which it drops to the floor level, where the end of the tube dips into a water seal shown in Fig. 2. In passing through

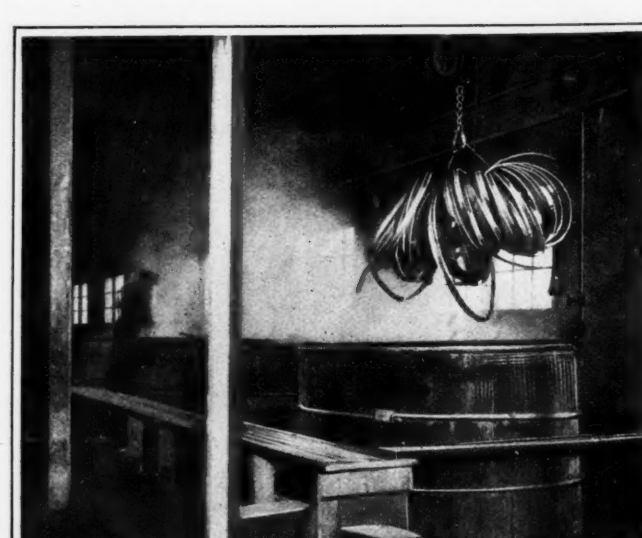


Fig. 5. Pickling Department—Attention is called to Method of dipping Steel

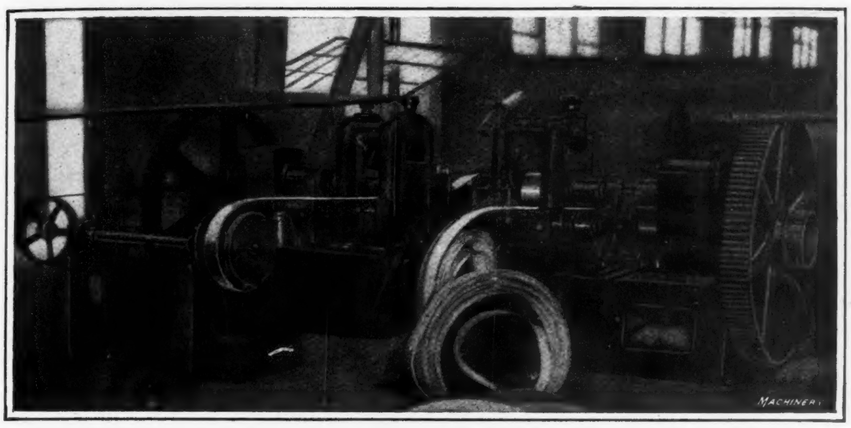


Fig. 6. Cold-rolling Strip Steel

the portion of the tube contained in the furnace, the temperature of the steel is raised to the degree required by the composition of the steel, after which it is carried along by the slowly moving conveyor, so that its temperature is allowed to drop very gradually, and this results in annealing the steel so that it is soft enough to be worked under the rolls. The steel is quite cold at the time it reaches the water seal at the far end of the tube, and although it is immersed in the water before leaving the conveyor, this does not result in the production of any serious amount of scale or rust. It takes about six hours for a coil of steel to pass through the furnace, and the rate of production is from 15,000 to 20,000 pounds in twenty-four hours. The furnace is in operation continuously.

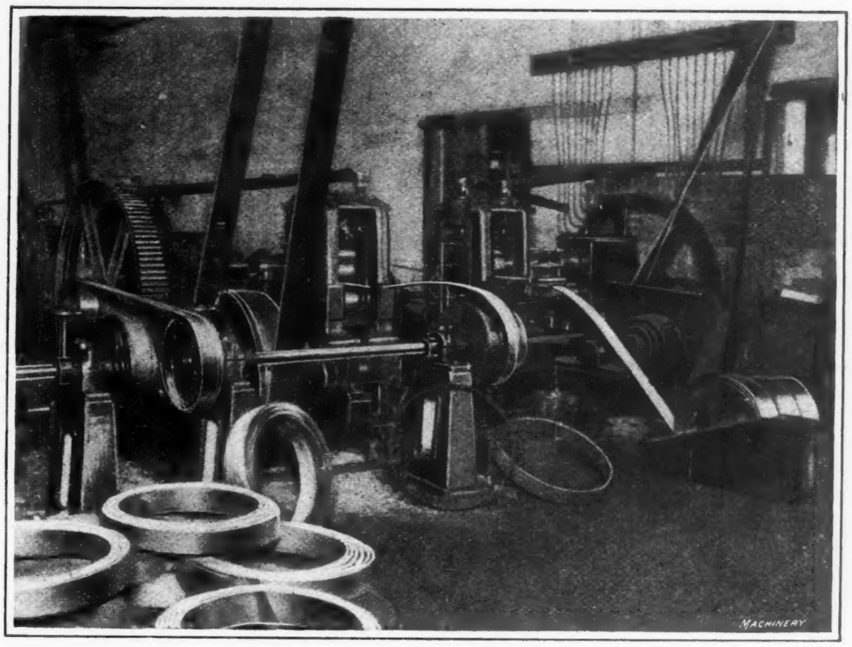


Fig. 7. Rolling Strip Steel—First Pass is made through Mill in Background, and Second Pass through Front Mill

Pot Annealing Furnace

In the pot annealing furnace, as in the type of furnace which has just been described, the object is to conduct the annealing operation in such a way that there will not be any tendency to form scale on the metal. In pot furnaces, the coils of metal are placed in steel pots and packed with fine iron borings, after which the cover is put on the pot and the joint sealed with fireclay. The iron borings serve to exclude air from the pot and also to assist in taking up oxygen from the small amount of air which is left; in addition, they have been found to possess the power of absorbing foreign matter from the surface of the steel which would otherwise result in the production of stains on the bright surface of the cold-rolled metal. Each of the pots in which the steel is annealed has a capacity of 1000 pounds of steel coils, and they are of the form shown in Figs. 3 and 4. It will be evident from these illustrations that there is a draft up through the center of the pot and lid, the purpose of this construction being to allow the heat to reach the metal from all sides. Eight pots can be held in each furnace at a time. It takes about twelve hours to anneal the steel in this furnace, making the capacity about 16,000 pounds of steel in twenty-four hours.

The furnaces in which the pot annealing operation is conducted are similar in form to muffle furnaces except that they are provided with doors at the front and back. Gas and air enter the furnace through ports arranged alternately all the way down one side. The flame rises to the arch, from which it is deflected to the opposite side of the furnace and escapes through a similar series of ports to those through which the air and gas are admitted. Running along the floor of the furnace there is a track for the wheels of trucks on which the annealing pots are carried. In connection with the annealing operation, the method of withdrawing the pots is important. It has been mentioned that there is a door at both ends of the furnace, and when one pot has been in the furnace for the required length of time, the back door is opened and this pot is withdrawn and allowed to stand for about eighteen hours in order to allow the steel to become quite cool before the cover is taken off. After withdrawing this pot, the back door is closed and the front door of the furnace is then opened and a truck carrying a pot of unannealed steel coils is pushed in, with the result that all the pots in the furnace are moved toward the back. It will be evident from this that the operation is continuous. Small "peep holes" in the furnace doors provide means of viewing the interior of the furnace without opening the large door.

Muffle Annealing Furnace

The muffle furnace, in which the steel is given what the cold-rolled steel maker designates a "scale anneal," is of exactly the same form as the furnace in which the pot annealing operation is conducted; but in operating this furnace the coils of steel are placed on trucks where they are exposed to the action of an oxidizing atmosphere. These trucks are passed through the furnace in the same way that trucks carrying the annealing pots are handled, and the steel comes out coated with an oxide scale which results in removing a certain amount of metal from the surface of the stock during the subsequent process of pickling. As previously mentioned, this method of an-

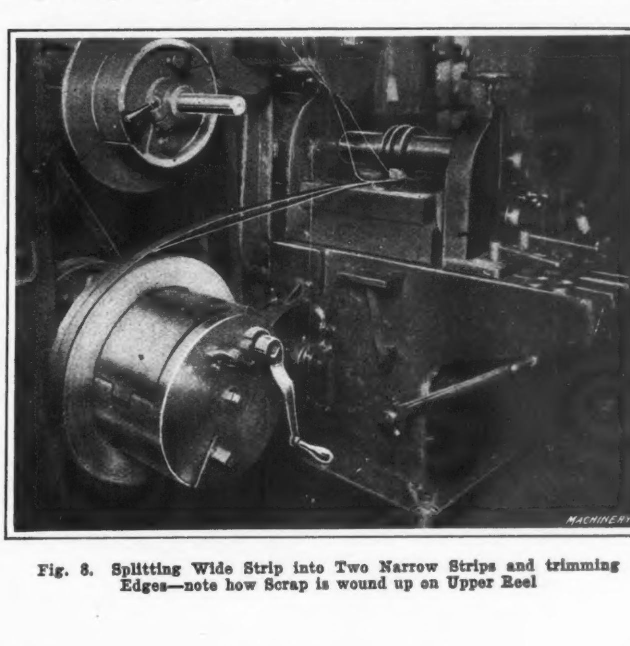


Fig. 8. Splitting Wide Strip into Two Narrow Strips and trimming Edges—note how Scrap is wound up on Upper Reel

nealing is only employed in the case of steel which has become decarbonized at the surface, the scale anneal serving to remove the decarbonized metal. It requires about 2½ hours to perform the annealing process in this type of furnace; and after being removed, three hours are required for the steel to cool sufficiently to be sent to the pickling department. The rate of production is about the same as that of the pot annealing furnace.

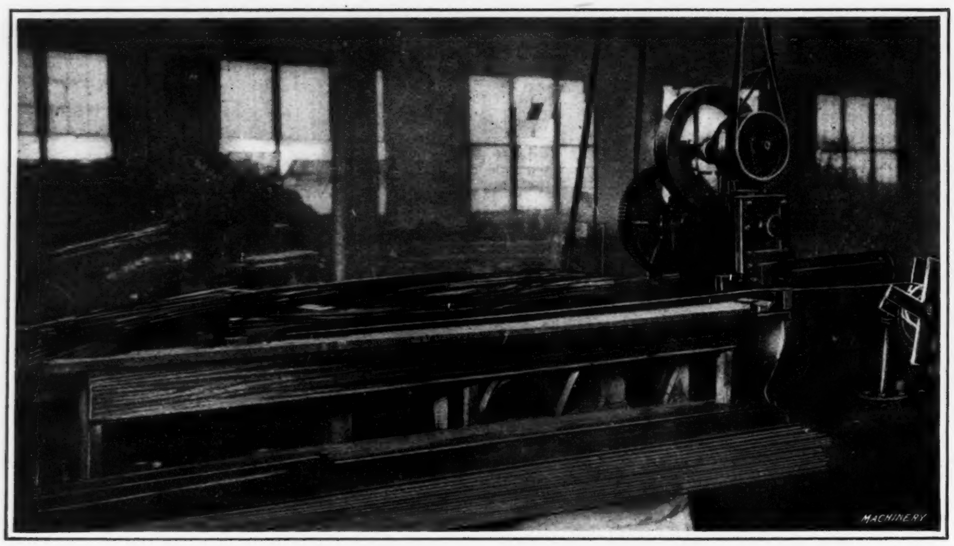


Fig. 9. Cutting Bench and Shear for cutting up Strip Steel into Stock Lengths

Pickling

The preceding description of the preliminary annealing process to which the steel is subjected refers to metal containing not less than 0.30 per cent of carbon, and after such steel has been annealed, it goes to the pickling department, where it is subjected to a treatment which removes all the oxide scale that was produced on the metal during the hot-rolling operations by which it was drawn out from the ingot into the form of ribbon stock. Steel with less than 30 points of carbon does not need a preliminary annealing, but goes direct to the pickling department. From this it will be evident that, after annealing, high-carbon steel is treated in the same way as steel with a low-carbon content, so that the following description applies to both classes of material.

The pickling process consists of immersing the rolls of steel in vats of sulphuric acid which acts upon the metal and causes the scale to be removed. This acid is contained in wooden vats which are furnished with steam pipes for heating the acid so that it will act more rapidly. The acid consists of a 5 per cent solution of sulphuric acid which has a density of 66 degrees Beaumé at a temperature of 60 degrees F. In pickling, the coils of steel must be loosened sufficiently so that the acid can easily find its way between the surfaces of the metal. The coils are supported on wooden frames which are lifted by a Yale & Towne electric hoist that runs on a track passing over the vats, the arrangement of the trolley and vats being shown in Fig. 5. These frames are dropped so that their ends are supported by the sides of the vat while the metal is immersed. In the case of low-carbon steel, the time that the metal is left in the vat is not important, as it may be immersed for as long as fifteen minutes without being damaged. With high-carbon steel, however, great care must be taken, as it requires about three or four minutes to remove the scale, while leaving the steel in the acid for a greater length of time will result in withdrawing carbon from the metal. The removal of the scale from the steel is the result of a combined chemical and mechanical action. The sulphuric acid reacts with the iron to liberate hydrogen gas which sets up a pressure between the steel and the scale and results in stripping off the scale. It is important for the stock to be uniformly covered with scale before pickling; otherwise, the pickled stock will have a "pitted" surface and, therefore, cannot be converted into good cold-rolled steel.

After the pickling operation has been completed, the steel must be washed immediately in order to remove the acid. This is done by lifting out the wooden frames from the acid vats and running them along on the hoist so that they may be dropped into similar vats filled with pure water which washes away the acid so that further action upon the steel is prevented. The removal of the acid would probably be effectually done by washing in water, but to make assurance doubly sure, the steel is removed from the water and plunged into a vat containing a dilute solution of lime water. The chemist has found that lime has the power to neutralize acid, but in the case of preparing steel for cold rolling, the use of lime water has a further advantage. This is due to the fact that when the steel is removed from the vats and given time to dry, it is coated with a film of lime which keeps both air and moisture from coming into contact with the metal, and so prevents it from rusting. It requires a "boss cleaner" and three helpers to look after a battery of two acid vats, one water tank and one lime water vat. The output is 2000 pounds of steel per hour.

Cold-rolling Operation

The cold rolling is done in mills built by the Rhenische Walzmaschinen Fabrik of Cöln-Ehrenfeld, Germany, shown in Figs. 6 and 7. Two sizes of mills are used which have rolls six and eight inches in diameter; and although both mills can be used for many sizes of stock, it is found economical to distribute the work among the mills according to its size. In cold rolling it is highly important to avoid chatter and vibration, as such a condition would be shown by irregularities in the surface of the product. This provision is well taken care of by having the power transmitted to the rolls through herringbone gears and shackle bars which serve as a double precaution against vibration and result in a very uniform transmission. The rolls are made of hardened chrome-vanadium steel containing a small percentage of tungsten, and are carefully ground to give them a very smooth finish. While in operation the rolls are water cooled by a continuous stream of water that flows through a pocket in the center of each roll. Those who are familiar with

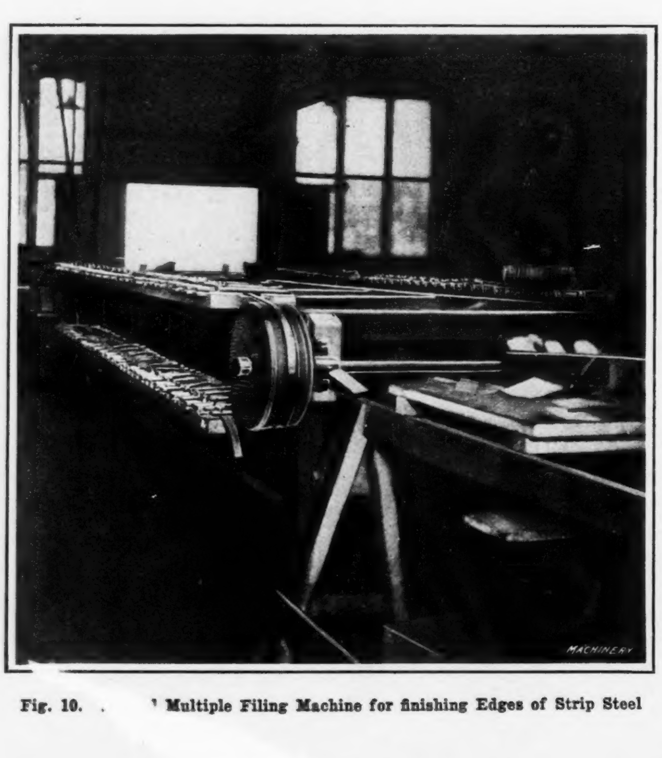


Fig. 10. Multiple Filing Machine for finishing Edges of Strip Steel

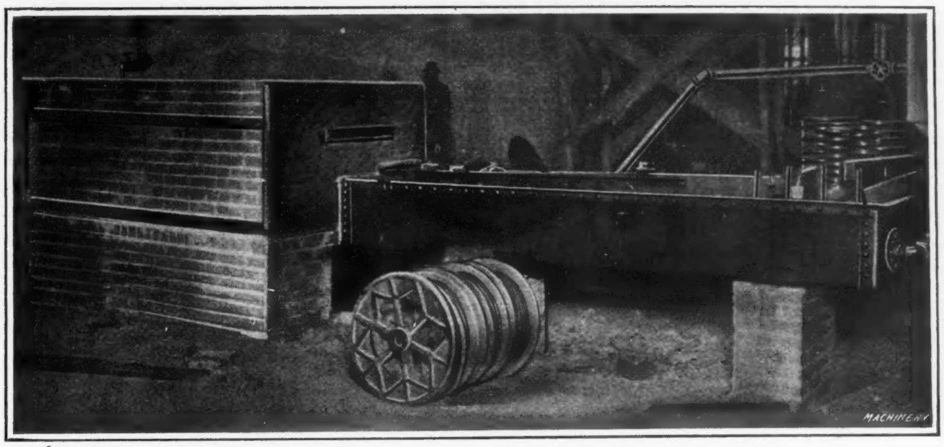


Fig. 11. Heating and Quenching Baths for hardening Strip Steel

cold-rolling mills will know that the position of the lower roll is fixed, while the upper roll may be adjusted to provide for the production of metal of various thicknesses. The chief roller becomes very proficient in setting the machines for rolling any gage of metal and is able to obtain very quickly the required adjustment. The setting is made by adjusting the rolls and testing the thickness of steel passed between them with a micrometer; then, if necessary, further adjustment is made until the desired result is obtained.

On the entering side of the mill there is a frame which supports an emery cloth wiper through which the steel runs in order to remove all foreign matter which might result in damaging the rolls. The mills are set to run in opposite directions, and arranged in series so that successive passes of the metal may be made through adjacent machines until the desired reduction has been obtained. The rolls are lubricated with a special grade of oil known as "Roll Oil," which is of about the same consistency as cylinder oil, but very carefully compounded to be sure that it is neither acid nor alkaline, as either condition would spoil the "bright" finish of the cold-rolled steel. After each two passes through the mill, the steel must be sent back to the annealing furnaces in order to remove strains which have been introduced through the mechanical working. In cases where the customer calls for steel which is "soft," it will be subjected to a final annealing operation after it has been rolled to the required thickness. Where "half hard" stock is called for, the steel receives one final pass through the rolls after being annealed. Other customers may order "hard" stock which has not been annealed, and their requirements will be fulfilled by subjecting the steel to two passes through the rolling mill after the last annealing operation has been performed.

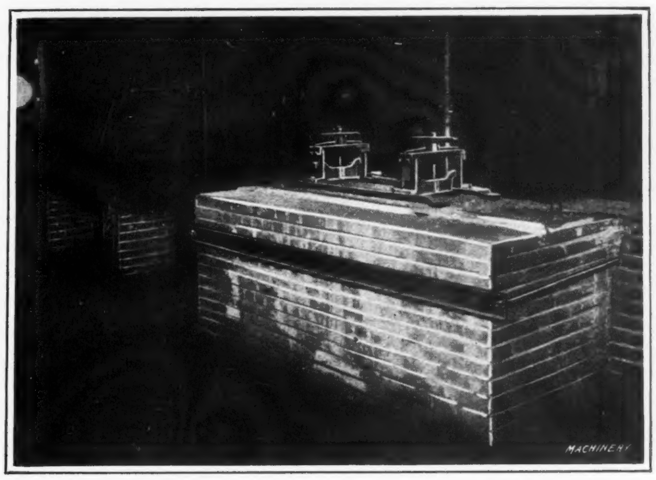


Fig. 12. Tempering Bath through which Steel is drawn after leaving Quenching Bath

The amount of reduction which can be obtained for each pass through the rolling mills depends upon the analysis of the steel; with low-carbon steel the reduction may be as great as 0.022 inch for each pass, and this will be gradually decreased until the final pass will only reduce the thickness of the metal about 0.005 inch. In the case of high-carbon stock, the reduction at each pass through the mill is much less; during the preliminary passes, this will amount to not more than 0.010 inch for each pass, while the reduction will be gradually decreased until the final pass reduces the thickness of the metal by only 0.003 inch. The degree of accuracy obtained in the gage of the metal is very great; in the thicker gages the variation will not exceed 0.0015 inch, while in the thinnest gages the limit of error is reduced to 0.00025 inch.

Trimming the Edges and Slitting Stock

After the rolling operation has been completed, the subsequent treatment of the cold-rolled steel will depend upon the use for which it is intended. For some purposes it is merely necessary to trim the edges so that the stock is of uniform width, while in other instances these edges must be finished in such a way that they are made quite smooth. Then for some uses, the steel must be hardened and tempered, while

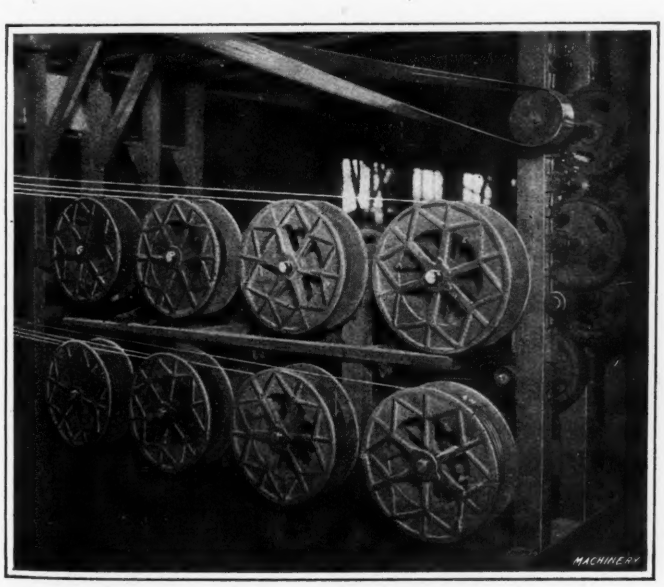


Fig. 13. Reels on which Strip Steel is wound after Heat-treating Operation is completed

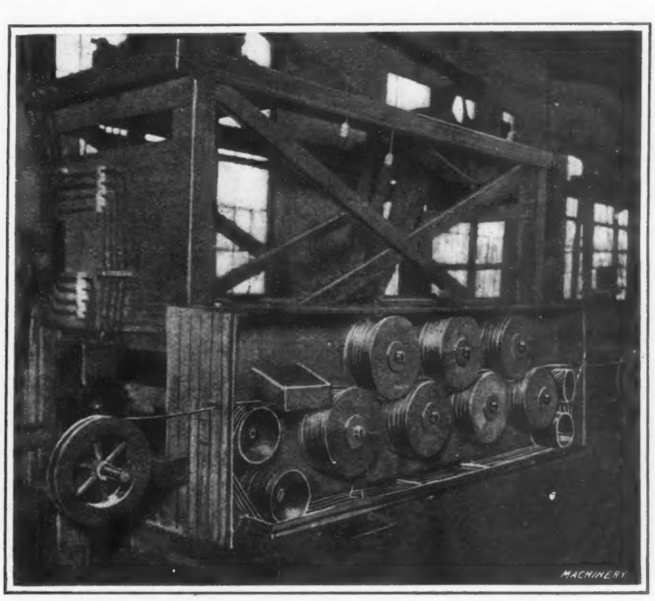


Fig. 14. Special Polishing Machine designed for applying High Finish to Strip Steel

other purchasers require it to be "dead soft." Some customers of the cold-rolled steel maker will also call for steel with a high polish, and still others are not particular about this point. As the production of all these features are important departments of cold-rolled steel manufacture, they will be described in the order in which the successive operations are performed.

For trimming the edges of the steel to reduce it to uniform width, use is made of a rolling mill fitted with rotary shear blades which are set at the required distance apart. The steel is passed through these blades from a reel on which the coil is supported; and after being reduced to standard width, it is rolled up on another reel at the opposite side of the mill. At the same time, a second reel winds up the trimming from the edges of the stock, and this scrap is pressed into bales and returned to the mill where the hot-rolled steel stock was produced. The same form of rotary shear is employed for slitting steel when it is desired to reduce stock of one width into two or more strips of lesser widths. The arrangement will be readily understood by referring to Fig. 8, which shows a mill set up for trimming the edges of the stock and slitting it into two narrow strips.

Finishing Edges of Stock

In those cases where it is required to have the edges of the strip steel brought to a smooth finish, use is made of a simple but ingenious multiple filing machine which provides for producing a smooth edge which may be either square or round. This machine is shown in Fig. 10, and consists of a table which supports a series of cross-slides made of wood that are grooved at both sides to receive tongues secured to the table. The ends of these slides are provided with short pieces of flat files, and the slides at opposite sides of the table are fitted with springs which tend to draw them together. In operation, the coil of strip steel, supported by a reel at one end of the table, is drawn between this series of files and then wound on a reel at the opposite end. It will be evident that in passing between the files, the edges of the steel are smoothed down; and by having all the files perpendicular to the plane of the steel a square edge is imparted, while arranging the files at a variety of different angles results in rounding the edges of the stock.

Cutting Strips Into Stock Lengths

After the edges of the cold-rolled steel have been trimmed—and finished in cases where the users' requirements make this operation necessary—some of the strip steel is cut up into standard stock lengths. For this purpose a measuring bench and shear are arranged as shown in Fig. 9; the coil of steel is mounted on a reel shown at the extreme right, and the steel is pulled between the shear blades so that a piece of the required length may be cut off, the length being indicated by a scale marked on the bench for that purpose. With this machine one man and a helper can very rapidly cut up steel into any lengths which may be required.

Hardening and Tempering

Purchasers of cold-rolled steel who use the material for making springs, and for various other purposes, call for steel which has been tempered; and for this purpose the cold-rolled steel maker must provide his mill with equipment for doing this work. One successful method of heat-treatment is applied as follows: The steel in the form of a coil is mounted on a reel and connected with a "leader" which provides for drawing it through the heating and quenching mediums at the proper speed. The steel is first run through a lead bath and its temperature raised to about 1450 degrees F., according to the analysis of the steel, after which it is quenched in oil; then the steel passes on through a second lead bath which provides for drawing the temperature at from 780 to 800 degrees F., after which the metal is wound on a second reel. A variable-speed motor is used for drawing the steel through the furnace, and this motor transmits power through a series of herring-bone reduction gears which provide for drawing the steel through at exactly the proper speed.

The lead bath is located in the furnace shown at the left in Fig. 11, and the oil bath in which the steel is quenched is contained in the metal tank at the right-hand side of this illustration. After passing through the oil bath, the steel is drawn through the tempering bath which is contained in the brick furnace shown in Fig. 12; this illustration also shows the hardening and quenching baths at the left-hand side. When the steel has been tempered, it passes onto the reels shown in Fig. 13, upon which the coils of steel are wound up. It will be evident from this illustration that provision is made for heat-treating eight coils of steel simultaneously; all the reels shown in Fig. 13 are driven from a single motor, power being transmitted through a train of high-reduction herring-bone gears which provide for drawing the steel through the hardening and tempering baths at the proper speed.

The preceding description applies to the method of heating the thicker gages of steel; in the case of the thinner gages, exactly the same method and form of equipment is employed, except that the metal is quenched in a lead bath which is kept just above the melting point, *i. e.*, at about 630 degrees F. This results in making the steel practically "glass hard"; but it is the plan to employ an alloy of lower melting temperature in order that it may be possible to have the steel even harder for those purchasers who demand such a condition. The object of quenching the thin steel in a lead bath is that it avoids the tendency to crack and become very crooked, which is a constant source of trouble where the steel is hardened in oil.

Polishing

For certain purposes there is a demand for cold-rolled steel with a high polish, and to meet the requirements of such users the steel is taken from the hardening and tempering department and subjected to a polishing treatment. This is done on machines provided with a series of rolls over which the steel runs, one of these machines being shown in Fig. 14. Upon entering, it passes through a box containing moist emery powder which must be extremely fine, powder from No. 80 to No. 100 being generally used. The steel carries away some of this emery with it, and in passing over the basswood rolls a rubbing action takes place which imparts a high polish to the steel. Upon leaving the machine, the metal passes between a series of wipers which effectually remove any emery which is left on the metal.

Conclusion

In referring to the desirable properties given to steel by the cold-rolling process, mention was made of the fact that cold-rolled steel is given a "bright" finish without any rust or oxide on the metal; but in order for the customer to secure the benefit of this high finish, great care must be exercised in packing the steel for shipment in order to prevent it from rusting while in transit. This is done by first wrapping the steel in oil paper and then covering the package with a thick layer of burlap. In the case of coils, the oil paper is wound around the steel and then the burlap is sewed around the entire coil; where the steel has been cut up into stock lengths, bundles of steel are wrapped in oil paper and burlap, and then the entire bundle is packed in a shipping box. In this way it is practically impossible for moisture to cause the steel to rust and lose its finish.

Cold-rolled strip steel is made by the Schwartz-Herrmann Steel Co. in widths ranging from 3/8 inch up to 4 3/16 inches; and the thickness of the product covers a range from 0.003 to 0.083 inch. On the thicker gages, the steel is guaranteed to come within 0.0015 inch of the specified thickness; and this limit of error is gradually reduced, so that it is possible to furnish the thinnest stock with a guarantee that the error in thickness does not amount to more than 0.00025 inch. To any experienced mechanic it will at once be apparent that the possibility of securing such a high degree of accuracy can only result through exercising absolute care in carrying out every step of the process of manufacture.

* * *

A novel use of the phonograph is made in weighing machines for speaking the weight. The weight is announced in a sonorous voice: "One hundred-and-fifty;" "two-hundred-and-three," etc.

INSPECTING LATHES*

WORK OF INSPECTION ENGINEER IN SEEING THAT SPECIFICATIONS ARE FULFILLED

BY JOHN J. RALPH†

THE purpose of this article is to explain the work of the inspection engineer who is employed by the purchaser of engine lathes to watch the process of manufacture and inspect the finished machines to see that all contract specifications are fulfilled. Three general topics are treated, *viz.*, the form of contract under which lathes are often purchased, the work of the inspector in investigating processes of manufacture, and current practice in inspecting finished lathes. Many shops that are having trouble with their lathe work because of the inaccuracy of the machines may find suggestions for overcoming the difficulty; and in this connection it cannot be too strongly emphasized that time and money spent in putting lathes into good working condition will pay large dividends in the form of an improvement in the quality of the work produced.

The Contract

The contract under which lathes are purchased usually specifies make of lathe, size, auxiliary equipment to be furnished, shipping dates and penalty (if any) for nonfulfillment of any part of the contract. Specifications are also incorporated which call for the use of sound material, first-class workmanship, and inspection during the process of manufacture and before acceptance. It will be noted that these items are very indefinite—especially the one relating to the quality of workmanship. The design of the lathe is not subject to inspection; and ordinarily no mention is made of the maximum duty required of the lathe or the degree of accuracy of the work produced on it. In addition to seeing that all terms of the contract are fulfilled, the inspector is usually required to expedite delivery and to report the progress which is being made by the manufacturer toward completing the order.

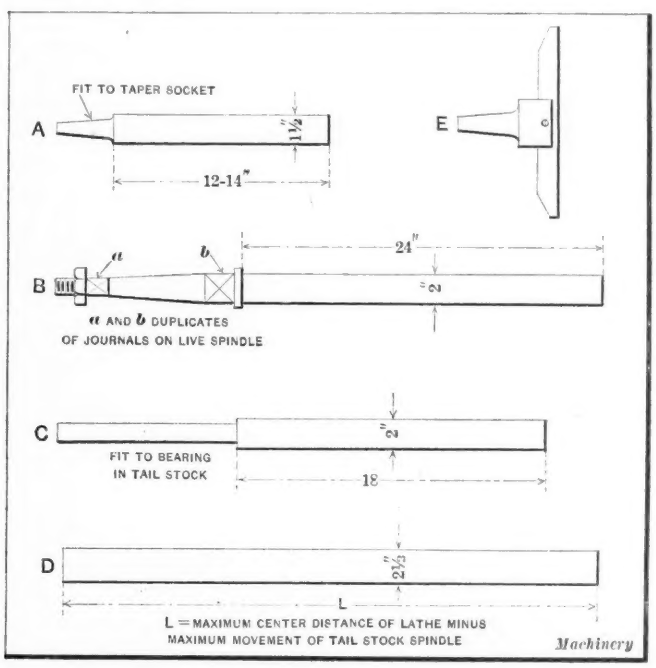


Fig. 1. Different Forms of Test Bars used in making Alignment Tests on Lathes

Relations between Inspector and Lathe Builder

In the machine tool trade, the employment of an inspection engineer to look out for the interests of the purchaser is a comparatively recent proposition, and the arrival of the inspector at the factory usually causes the employes to experience mixed emotions, none of which are likely to be pleasant even in the case of factories that build first-class tools. If he is tactless, inexperienced or dishonest, he is sure to cause trouble and expense, particularly in cases where the machine tool builder feels that his product does not need inspection. There is a deeper reason, however, for disputes arising through the employment of an inspection engineer: this is that there is often no recognized standard of accuracy in the shop; and as there is no maximum allowable error and no minimum limit of accuracy, it will be evident that there is plenty of room for an honest difference of opinion. "Good" and "first-class" workmanship are purely relative terms, and are subject to as wide a range of interpretation as the proverbial "hair" which varies from the eighth inch of the blacksmith to the fraction of a thousandth inch of the toolmaker. If the machine tool builder has no standard of reference, and his competitors have none, a dispute is likely to arise that is not adequately covered by the terms of the contract and in which, according to the terms, the purchaser's ruling is final.

The question of delivery is also likely to cause trouble, as the average shop is exceedingly lax in maintaining manufacturing schedules and has become accustomed to having the sales department make reductions in promised dates of delivery which were originally quite short. The presence of a purchaser's representative in the shop will be likely to assist the purchaser in gaining prompt deliveries, and this is one of the points which must be looked after by the inspector, although he should remember that the machine tool builder has many other customers who are also pressing him for deliveries, and he should avoid taking an unreasonable stand. Also, it should be borne in mind that extreme rapidity in manufacturing is likely to result in a proportional reduction in the quality of workmanship, so that the inspector should not make the error of over-emphasizing the importance of early delivery. Before leaving the question of the relations between the inspector and machine tool builder, attention should be called to the fact that the presence of an inspector in the factory is really a benefit to the builder of first-class machine tools, as it insures the fulfillment of all of the purchaser's requirements before shipment is made, and so avoids the possibility of subsequent trouble and expense. Furthermore, satisfactory reports from the inspector are often the best possible form of sales literature and bring repeat orders to the machine tool builder with no effort on his part beyond the submitting of quotations.

The Inspection

The inspection starts with the receipt of raw materials in the factory and includes a constant observation of the manufacture of all parts in order that defective workmanship may be promptly detected and rejected. Then, when the machine has been assembled, tests are made of the alignment of all working parts and correct operation of the mechanism. The inspector is expected to make a count of all items before shipment and to be sure that the method of packing is such that there will be no danger of damage in shipping.

Upon his arrival at the factory, the inspector's first step will be to make a complete study of the manufacturing operations involved in producing each machine in which he is interested. This is necessary so that he may know how the parts are made and whether there is possibility of trouble through the use of jigs which are likely to become inaccurate or operations that depend upon the workman's judgment. Particular attention should also be paid to the condition of all the machines used in the factory, in order that those that are liable to turn out defective work may be watched. There are often

* For other articles published in MACHINERY dealing with the subject of testing machine tools, see "Efficiency Test of a Stockbridge Shaper," May, 1914; "Milling Machine Dynamometer," November, 1913; "Inspection Tests for Cincinnati Gear Cutting Machines," October, 1913; "Lo-swing Lathe Test on Motor Armature Shafts," April, 1913; "Method of Testing Lathe Spindle Alignment," June, 1912; "The Testing of Spirit Levels," April, 1912; "Aligning the Spindles of a Multiple-spindle Drill Press," October, 1911; "Testing a Cylindrical Grinder," July, 1911; "Machine Tool Testing," February, 1911; and other articles there referred to.

† Address: 156 Blossom St., Fitchburg, Mass.

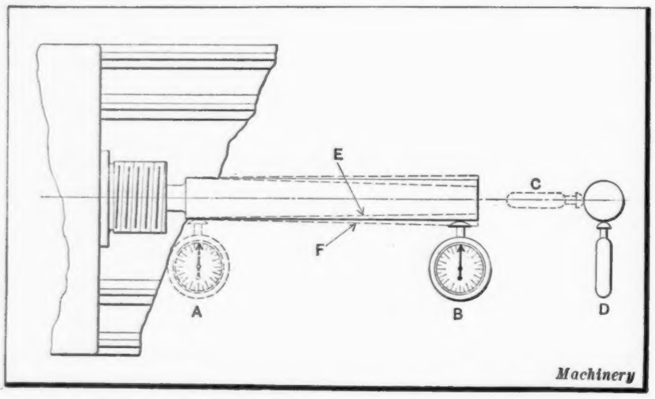


Fig. 2. Diagram showing Method of Procedure in testing Alignment of Lathe Spindle with Ways

places where partial inspections can be made, which will make it necessary to perform only an occasional final test of such parts in the assembled machine. Making a preliminary survey of manufacturing conditions in this way will often enable the inspector to predict accurately whether the order will be finished on time; and it will also enable him to form a general idea of the probable quality of the finished lathes, which could not be secured from an inspection after all parts have been assembled.

In testing the finished lathe, the following are the most important requirements that must be fulfilled: (1) All parts that move on the bed must travel in a line exactly parallel to the ways on the bed. (2) The axis of the spindle must be absolutely parallel with the ways, regardless of whether the machine is to be used for turning work between centers or machining pieces supported by a faceplate or chuck. (3) A line connecting the live and dead centers, for any position of the tailstock, should be parallel with the ways and should represent a continuation of the axis of the spindle. (4) The carriage bearings must be accurately scraped to fit the ways, and the carriage must move smoothly along the bed without any perceptible play. (5) If the carriage is fitted with a cross-slide, the slide must move in a line perpendicular to the axis of the spindle measured at a point horizontal to the center line of the spindle. (6) The power must be transmitted without vibration, and the speed change mechanism must operate easily. (7) The feed mechanism must operate easily.

The castings are inspected before machining operations are started and all those that show imperfections on working surfaces are rejected, as experience has shown that such defects cannot be satisfactorily remedied by ordinary shop methods. If defects are found in other parts of a casting, and these are of such a nature that they do not impair its strength, the casting may be passed by the inspector; but he will have to see that such defects are corrected before the part is sent to the assembling department. The ways on the bed are tested before the machine is assembled, a straightedge and master plate to which the ways are accurately scraped being used for this purpose. The accuracy of the carriage may best be determined by watching the workman as he scrapes its bearings to fit the ways on the bed, although tests made of the assembled machine will also expose any serious defects.

After the lathe has been assembled, and before any of the tests are made, it should be set up perfectly level, a sensitive spirit level being used to test both across and along the ways to see that this requirement has been fulfilled. Care should be

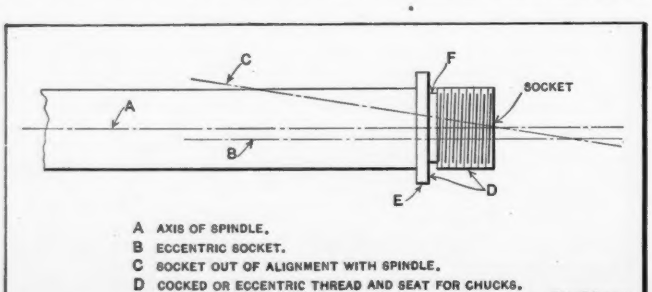


Fig. 3. Conditions that may be found in testing with Bar in Socket

taken to see that the legs are firmly supported and that all bearings have been properly adjusted. Then the fit of the centers in their sockets is tested with prussian blue to see that they seat themselves properly. After this has been done, the tailstock is moved back out of the way and bar *A*, Fig. 1, is inserted in the spindle in place of the center. Such a bar is very useful in making lathe tests, as it determines the accuracy of both the spindle and socket. After bar *A* has been put in place, an indicator is mounted in the toolpost and brought into contact with the bar, after which the spindle is slowly revolved and readings of the indicator are taken at both ends of the bar, as shown in Fig. 2. In making this test, no variation should be found at the spindle end of the bar, and at the outer end the variation should not exceed 0.00025 inch.

In cases where variation occurs, the high side of the bar is marked with chalk; and if the high sides coincide at both ends and the variations in the readings are equal, it shows that the socket is eccentric with the axis of the spindle; if different variations are found at opposite ends of the bar, it may show that the socket is out of alignment with the spindle. In Fig. 3, the condition of eccentricity of the hole is indicated by line *B*, and line *C* shows the condition where the error is in the alignment of the socket. If in making the tests at opposite ends of bar *A*, Fig. 1, the error shown by the indicator does not exceed the maximum allowable variation, the instrument is run along the bar from *A* to *B*, Fig. 2, first at the front of the bar and then at the top, as indicated at *C* and *D* in the end view; and in making this test the variation should

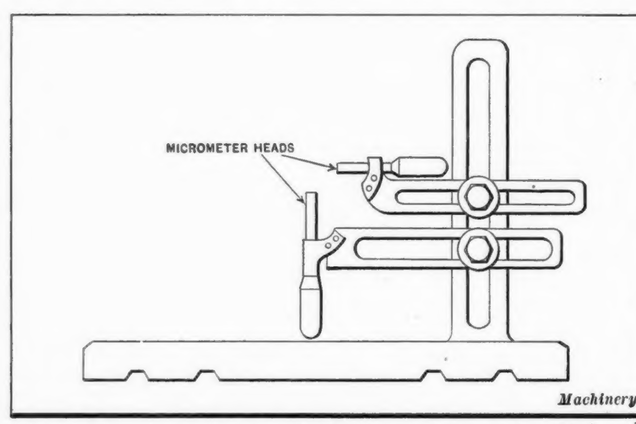


Fig. 4. Measuring Tool used with Bars B and C for testing Alignment of Headstock and Tailstock

not exceed 0.00025 inch. It is assumed that the test bar is perfectly accurate, but if there is any error in it, a suitable allowance should be made. All the bars shown in Fig. 1 are hardened and accurately ground to size, and the diameter should not vary over 0.0001 inch from end to end; the diameter is immaterial, but the bars should be tested for straightness at frequent intervals.

If the test conducted with a bar mounted in the lathe spindle shows satisfactory results, that is all that is desired; but when an error is discovered, it is difficult to tell where the inaccuracy is located. To determine the position of the error, bar *B*, Fig. 1, is used to test the accuracy of the alignment of the headstock with the ways. One end of this bar has bearings *a* and *b* of the same shape as those of the spindle, while the other end is a perfectly true cylinder. This bar is hardened and accurately ground to size so that it may be mounted in the headstock in place of the spindle. The alignment is then tested with an indicator, in the same way as with the bar mounted in the spindle, and if more than the allowable inaccuracy is discovered, the headstock is scraped until the error has been corrected as shown by indicator tests made at opposite ends of bar *B*. Fig. 4 shows a form of tool that will be found convenient in making a test with this bar; and after the headstock has been lined up in this way, the required degree of accuracy will be obtained.

When the test made on the bar mounted in the spindle bearings shows satisfactory results, the lathe spindle is replaced and the test repeated with the bar mounted in the spindle. In cases where the trouble is due to an error in the alignment

of the socket in the spindle, the following method of correction is employed: The high points on the bar are noted, together with the total variation of the indicator reading; and one-half of this difference indicates the true eccentricity of the socket with the axis of the spindle. This point is clearly brought out in Fig. 2, where it will be seen that the desired position for the bar lies midway between the high reading at *E* and the low reading at *F*. If the spindle is parallel with the ways (which has already been determined by the test made with the bar that fits in the spindle bearings, and by scraping to remove any existing error), it is possible to rebore and ream the socket to correct for the error in alignment or concentricity which was introduced the first time it was machined.

After the headstock tests have been made, the next point is to determine the accuracy of the tailstock, and on lathes where the tailstock is adjustable to provide for taper turning operations, it should first be set exactly at the zero point. The tailstock should then be moved along the bed until the centers in the headstock and tailstock touch when viewed from above. Fig. 5 shows an accurate method of observation, which consists of putting a sheet of white paper below the centers and using a magnifying glass from above. The tailstock center is usually 0.0005 to 0.0015 inch higher than the live center to provide compensation for wear, the amount depending upon the size of the lathe. This is a custom generally followed in the trade, but the increased use of hardened steel centers and the careful attention which is now paid to keeping them in good condition seem to indicate that it is not so necessary as was formerly the case.

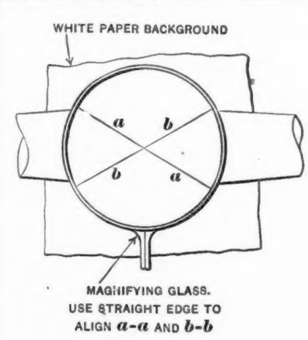


Fig. 5. Testing Alignment of Centers in Headstock and Tailstock

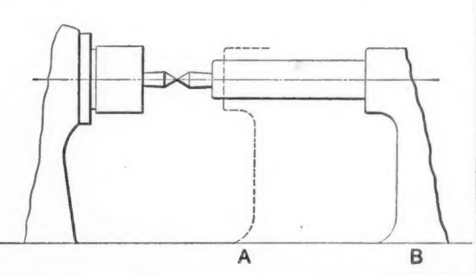


Fig. 6. Same Test as shown in Fig. 5, but with Tailstock Spindle fully extended

The tailstock is next moved back until the centers just touch with the tailstock spindle fully extended as shown in Fig. 6, after which the relative position of the centers is again viewed as shown in Fig. 5. This test serves as a check upon the alignment of the tailstock spindle with the ways, and after it has been completed the center is taken out of the tailstock spindle and replaced in another position in which the test is repeated to prove that the socket is in correct alignment with the tailstock spindle. In Fig. 7, line *D* indicates the effect of an error of alignment of the tailstock spindle, and if trouble of this kind is discovered it must be corrected by rescraping the tailstock bearings on the bed. If the tailstock spindle is parallel with the ways, but the socket is found to be eccentric with the spindle as indicated by line *E*, the centers may be brought into the required alignment by reboring and reaming the hole in the spindle. Such an error in a new lathe must not exceed very small limits.

The tailstock is next moved back to the end of the bed and bar *D*, Fig. 1, is set up between the centers, after which the indicator is mounted in the toolpost and readings are taken along the front and top of the bar as indicated in the end view, Fig. 2. The instrument must be carefully watched while making these observations, and the movement of the carriage must be slow and uniform, so that the effect of backlash will not be noticeable. After making the first test, the bar is turned through an angle of 90 degrees and a second series of readings is taken. If the results are satisfactory, it proves the accuracy of alignment of the outer ways with the line of

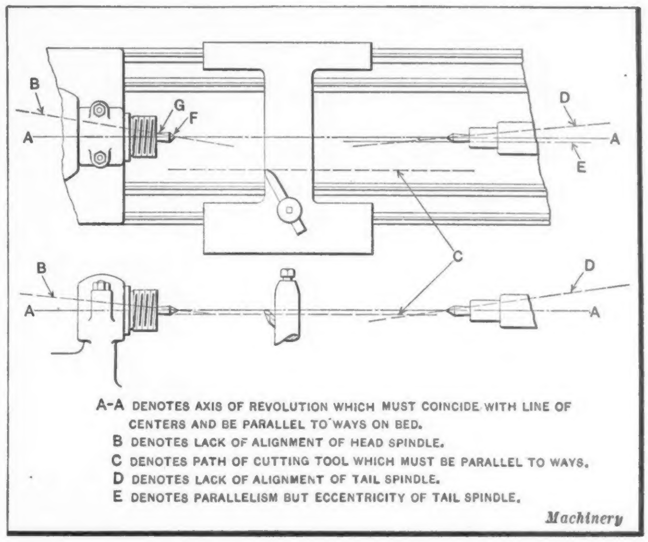


Fig. 7. Conditions of Alignment required between Headstock and Tailstock Spindles

centers. The tests are then repeated with the tailstock spindle fully extended to determine the actual error in alignment of the spindle. If the readings do not vary more than 0.00025 inch, the lathe may be passed, although the discovery of such an error means that, in turning, the maximum accuracy of the work can only approach that limit instead of true accuracy. It will, of course, be evident that in taking these readings allowance must be made for the difference in height between the head and tail centers, and for any variation that may exist in the size of the bar.

The lead of the screw is tested by closing the split nut on it and measuring the movement of the carriage along the bed with calipers. Care must be taken not to reverse the driving mechanism, as this would introduce apparent error due to the effect of backlash, making the results of the test inaccurate. It is hard to say what the limits of accuracy of the screw should be, but in a lathe of fair quality it does not seem unreasonable to specify a maximum total error of 0.010 inch over the entire length of the screw, with a maximum error of 0.0015 inch per inch of length.

The faceplate is next put on the spindle, and it should be a snug fit, although movable by hand. If the machine tools and jigs used were accurate, and if the live spindle were carefully centered, turned and ground, the faceplate should be almost exactly perpendicular to the axis of the spindle. To test this, the compound rest is set at zero and the indicator clamped at the center height, after which a reading is taken right across the faceplate. The spindle is then turned through a quarter revolution, and a second reading is taken across the faceplate. If the results of these two tests correspond, it shows that the faceplate is true; but if

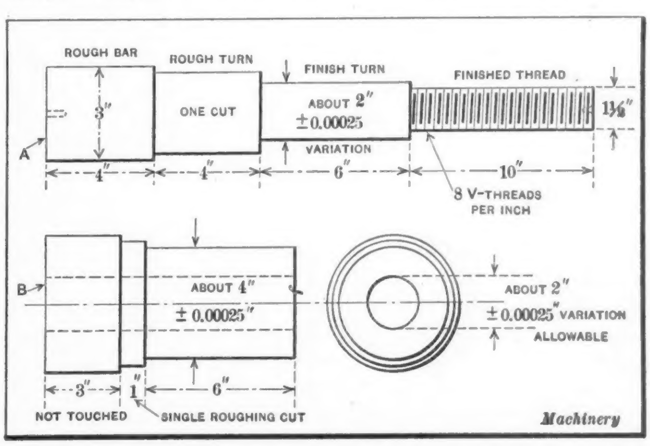


Fig. 8. Examples of Work turned on Centers, and Chuck Work done while conducting Running Test on Lathe

any discrepancy is discovered, the first step is to take off the faceplate and look for chips, sharp edges left by the turning tool or slight bruises.

If no such trouble is discovered, the faceplate is replaced on the spindle, taking particular care to see that it is accurately seated, after which the test is repeated; and if the two sets of readings still fail to agree, a cut must be taken across the faceplate. Many good mechanics claim that this should be done in all cases where great accuracy is expected of work done on the faceplate. Before taking this cut, the cross-slide setting should be tested; and this may be done by taking a cut across the face of a piece of stock held on the faceplate and testing this surface with a straightedge or surface plate. Another method is to make the test with an indicator held in the toolpost. If the cross-slide is accurate, the indicator reading obtained in traversing across the machined face should be uniform. Still another method is to use a testing square which is placed in the spindle with the blade in a horizontal position as shown at *E* in Fig. 1, after which an indicator reading is taken across the blade of the square. The square is then turned through 180 degrees and a second reading is taken. If the difference in readings is the same in both positions, it shows that the cross-slide is perpendicular to the ways. It will, of course, be evident that the use of this testing square is a substitute for the method of facing the piece of work mounted on the faceplate.

The next step is to test the thread of the spindle nose with a micrometer, using the three-wire method. The indicator is then applied to the spindle at points *D*, *E* and *F* in Fig. 3. This section of the spindle is usually machined at a different setting than that employed for grinding, and unless extreme care is taken it may be eccentric. If an error is discovered, it should be corrected by lapping. The chucks are tested by gripping a ground cylindrical bar and noting the difference in the indicator readings at opposite ends of the bar. The allowable error depends upon the size and quality of the chuck being tested; and in this connection it may be mentioned that the purchase of cheap and inaccurate chucks is false economy, as pieces machined in such chucks are likely to require a lot of subsequent hand fitting. The taper turning attachment is tested by mounting bar *D*, Fig. 1, between centers; the taper attachment is then set for some particular taper per foot, after which indicator readings are taken for each inch through a distance of 12 inches. If the taper attachment is accurate, it will be evident that the difference in readings will be 1/12 of the required taper per foot.

Working Tests

It may be possible for a lathe to pass all the preceding tests satisfactorily and still produce inaccurate work, so that after testing the alignment of all the machine members it is necessary to conduct a working test. For this purpose two pieces are usually machined—one held between centers and one in the chuck or faceplate. In making this test the operation of all parts of the mechanism should be carefully watched. The bearings should be oiled and carefully watched during the test to see that the lubricant is circulated properly. Particular attention should be paid to operating the lathe under each of the available combinations of speed and feed, taking care to see that the clutches and gears operate smoothly. Fig. 8 shows examples of the type of pieces employed for making the two working tests. For testing the operation of the lathe on work held between centers, piece *A* is first roughed out for its full length, a sufficiently heavy cut being taken to show the power of the lathe. After this has been done, finish cuts are taken to prove the accuracy of work produced on the machine.

Piece *B* is next chucked and turned. As in the case of work mounted on centers, the roughing cut should be very heavy to test the power of the lathe, while the finishing cuts should be made with a view of determining the accuracy of work which can be produced. In performing the boring operations, the final cut should first be taken by running the tool from the outer to the inner edge of the work; and then, without stopping the lathe, the tool should be fed in for a distance corresponding to the depth of the cut just taken. A similar boring cut is then taken while traversing the tool to the outer end of the hole. This method equalizes the error due to the wear on the cutting edge and deflection of the unsupported end of the tool. The inspector should be thoroughly familiar with the limits of accuracy required in handling lathe work on different sizes and types of machines, and he should not demand greater accuracy than is actually required. The final point to be looked after in conducting a working test is to look over the machine carefully to see that the bolts and fastenings are properly tightened, that all gear guards and other auxiliary parts are in place, and that all members of the mechanism operate satisfactorily.

Packing

After the machine has been inspected and accepted, it is marked, and all the equipment that goes with it is sent to the shipping room with the lathe. Here all parts of the machine that would be likely to become damaged if shipped in place are removed and packed separately. The machine is thoroughly cleaned and all bright parts are "slushed" over with a rust-resisting compound, after which the machine is carefully crated and marked for shipment.

* * *

TRANSLATOR'S PIGEON ENGLISH

Catalogues and leaflets describing machine tools are frequently published in several languages to facilitate sales in foreign countries. The translations are made by men who may be linguists of more or less ability, but who are seldom remarkable for their mechanical knowledge and a correct understanding of mechanical terms. Hence the language is sometimes rather strange, and although it may express the meaning, the wording leaves something to be desired. An example of this kind is given in the following, which is a translation from a catalogue published in three languages and referring to certain types of machine tools.

Terms of Delivery

Prices.—They are understood according to special written offer without packing loco neuses.

Payment.—All invoices are understood with 2 per cent cash discount. Long credit according to agreement. References should be given.

Packing.—Unless spezial instructions are given, the packing is done carefully according to our best judgment.

Despatch.—The goods are despatched in all cases for risk and account of the consignee. In the case of free delivery according to special agreement, the amount of the freight will be credited on the invoice on presentation of the bill of lading or forwarding note.

Term of Delivery.—The agreed term of delivery will be observed as far as possible. Defective material or breakdowns in the factory prolong the term of delivery. Mobilisation, war and events beyond the control of man, disengage me from the obligation of delivery.

Claims.—They are only acknowledged if made within eight days from the arrival of the goods at their destination.

Guarantee.—Defects which have proved to be due to faulty construction, workmanship or material, are remedied free of charge in my factory within one year. The replaced parts are my property. Other claims are not acknowledged. The parts to be repaired or replaced should be forwarded to my factory, carriage paid.

Illustration.—They are unbinding because improvements can give rise to slight deviation.

* * *

Motor cars are becoming so numerous in many American cities that finding sufficient parking space in the "downtown" sections is a serious problem. During business hours thousands of cars are parked along the principal business streets of Detroit. Fortunately, many of the streets are of sufficient width to permit cars to be driven in to the curb at an angle that permits any car to be readily backed out though other cars are closely parked alongside. In other cities having narrower streets, traffic space is so narrow that motor cars must be drawn up closely paralleling the curb. In Milwaukee it has become necessary to take a section off around some of the parks in order to provide space for cars. In time, it seems that it will be necessary for cities to provide large central areas for the storage of motor cars, and where space is at a premium these places may be two- or three-story open side structures, with ramps that permit easy access to the upper floors.

MANUFACTURE OF CIRCULAR METAL SAWS*

SELECTION OF STEEL, STAMPING OUT BLANKS, CUTTING TEETH, HEAT-TREATMENT AND ETCHING

BY FRANK M. SHAW†

MANY of the contracts for shrapnel and high-explosive shells which have been placed in this country during the past eighteen months provided for the payment of bonuses as a reward for early completion, and this led to the speeding up of every operation as far as possible. Those who are at all familiar with the manufacture of shells know that there is a large amount of cutting off to be done, and as the material is a tough grade of steel, it will be evident that the strain on the saws used for this purpose is quite severe. This has created an unusual demand for circular saw blades, and more particularly for those made of high-speed steel, which are adapted for severe service conditions. Circular saws are made from a number of different grades of steel, and each of these will be referred to separately.

Carbon steel is seldom used in the manufacture of circular saws over 12 inches in diameter—so seldom, in fact, that the use of this material does not warrant discussion. Low tungsten steels are made from a variety of different alloys, all of which possess special merits in the manufacture of saws; but a very good saw—and one which is preferred by many users—is made from a vanadium steel that does not contain any tungsten. Some of the alloys contain a greater percentage of tungsten than others, and the trade names by which they are known usually designate the constituent of the alloy which predominates or the presence of which must be considered in heat-treating. Thus, there are manganese-tungsten steels, chrome-vanadium steels, etc. Each of these alloys requires a different method of heat-treatment, and great care must be exercised to see that the temperature of the metal is raised to exactly the required degree before quenching. If the temperature is raised too high the steel will be damaged, and subjecting it to a subsequent heat-treatment will not always result in obtaining results as good as those which might have been secured by applying the correct heat-treatment in the first place.

High-speed steel is being used to a greater extent every year in the manufacture of circular saws. This steel contains from 8 to 18 per cent of tungsten or its equivalent of molybdenum, and comes in various alloys; but tungsten is a constituent of most high-

* For additional information on this subject, see "Making Saws," published in MACHINERY, March, 1909.

† Address: 94 Dunmoreland Ave., Springfield, Mass.

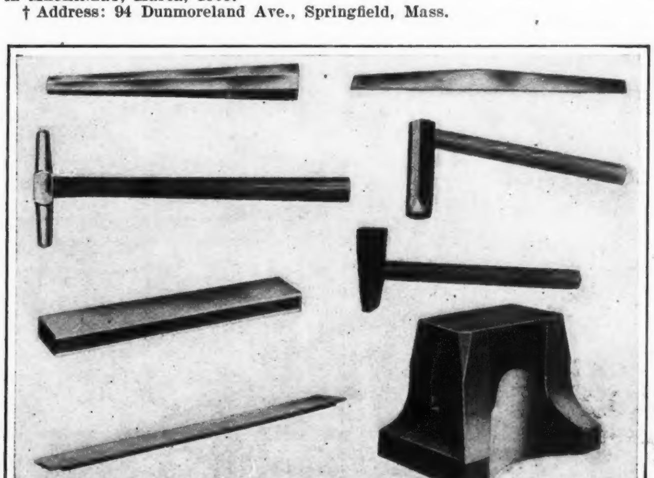


Fig. 1. Anvil, Hammers and Surface Plates used by Sawsmiths in Straightening Plates from which Circular Saw Blades are made

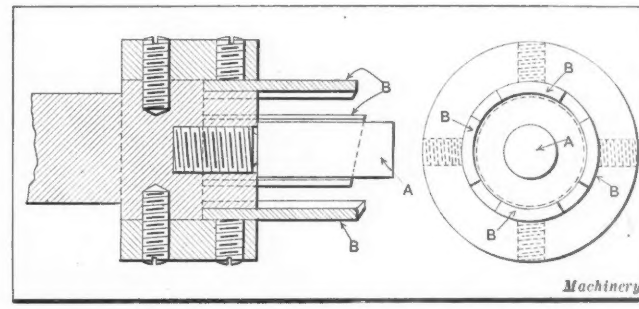


Fig. 2. Tool used for boring Arbor Hole in Circular Saw Blades

speed steels used in the manufacture of circular saws. Some of the high-speed steels used for this purpose are of the type which must be hardened by quenching in oil, while others are of the so-called self-hardening variety. The writer's experience has been that steels hardened in oil make tougher saws than those of the so-called self-hardening type.

When the plates of steel are received in the factory, they are in the form of round disks, and the first step is to measure them for thickness and diameter, after which they are placed in racks ready for subsequent use. The plates of low tungsten steel are 0.015 inch above the required thickness, while high-speed steel plates are 0.032 inch too thick. This allowance is provided to enable the saws to be ground to exactly the required thickness. Owing to the higher temperature which it is necessary to employ in hardening high-speed steel, it is necessary to have the blanks thicker than in the case of the low tungsten steels, because provision must be made for grinding away a greater amount of metal after the hardening operation has been completed. The diameters of plates of both of these classes of steel are ⅛ inch over size when delivered to the factory.

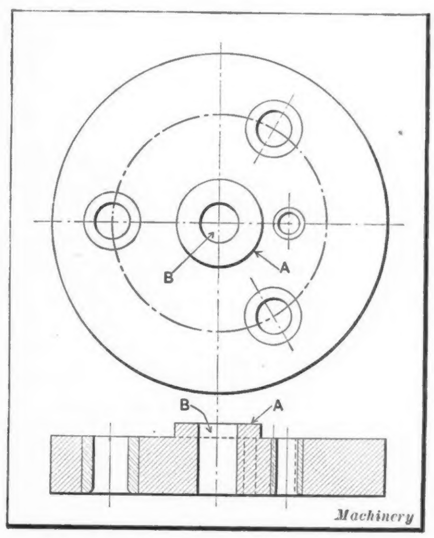


Fig. 3. Jig for drilling Holes

The first operation involved in the fabrication of these round plates into circular saws consists of flattening them, as their shape is likely to be very irregular. This is done on a special anvil, and use is made of a variety of hammers ranging in weight from 3 to 7 pounds. These hammers are of special shapes which experience has shown to be best suited for the requirements of the work, several of which are illustrated in Fig. 1. This flattening or straightening operation calls for peculiar skill that can only be gained through experience; the men employed in this work are known as sawsmiths. It is an axiom of circular saw manufacture that the less hammering done on the hardened saw the better; in fact, nothing but a peening hammer should be used.

In order to cut the arbor hole in the saws a ½-inch pilot hole is first drilled, after which the special tool shown in Fig. 2. is employed to cut the arbor hole, provided the size of this hole does not exceed 2 inches in diameter. As most saws under 30 inches in diameter have a smaller arbor hole than this, there is not enough boring to warrant making special tools for larger sized holes, and so standard boring tools are used. In the special tool shown in Fig. 2, *A* is the pilot which enters the ½-inch hole; and *B* are the cutters, each of which is 3/32 inch thick by 5/8 inch wide, and ground 0.016 inch under the hole size. Holes exceeding 2 inches in diameter are machined with a boring tool driven by a drill press. In the case of saws which have driving holes, these are drilled by setting up the blade in a jig which locates the holes in the

desired positions. This jig, which is shown in Fig. 3, is of simple construction and easily handled; it is made of a plate 1 inch thick by 6 inches in diameter, with a boss *A* about ¼ inch high which fits into the arbor hole in the saw blade. A ⅝-inch hole *B* through the center provides for passing through a bolt by which the saw is fastened to the jig. The usual form of hardened bushings is furnished for locating the holes in the work. In the case of saws which are sprocket-driven, the holes for the sprocket teeth are punched after the arbor hole has been machined in order to insure concentricity, and the driving sides of these holes are then filed around to allow them to mesh properly with the sprocket. If the corner is simply filed off, the metal around the hole is likely to chip or break away.

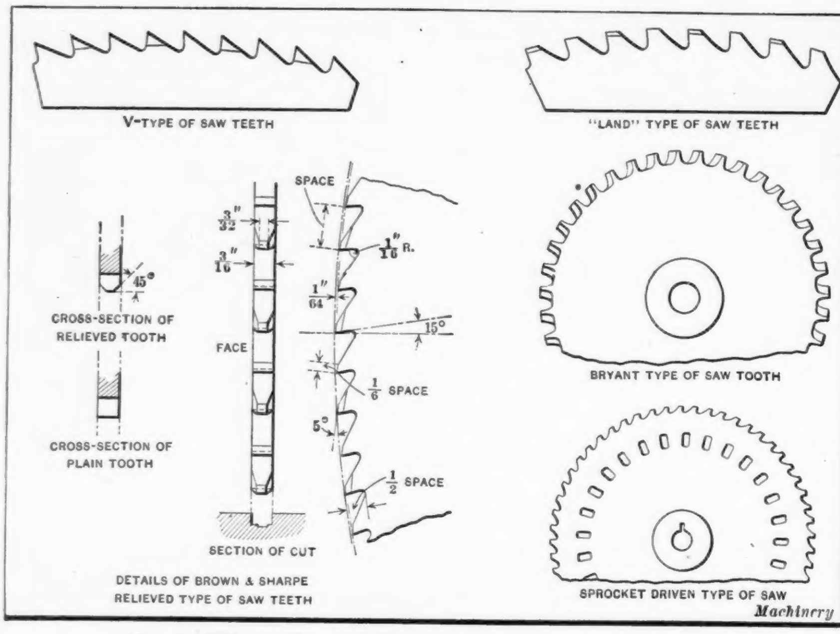


Fig. 4. Different Types of Teeth commonly used on Circular Saws

As the rim of the steel plates is very irregular and it is inadvisable to grind them round, owing to the danger of burning the metal, recourse is sometimes had to the use of stamping dies for trimming the blanks to size under a power press. A more satisfactory method is to trim them up on a gear-cutting machine which is made to trim the plate and cut the saw teeth at the same setting of the work. A number of different shaped teeth are employed, the following being those most commonly used: (1) The V-shaped tooth which is cut to a sharp point or edge and has its front face either radial or under-cut. (2) The type of tooth which has a land at the top instead of being cut to a sharp point; this style of tooth may also have its front face radial or under-cut, the under-cutting varying from 10 to 15 degrees and the width of the land varying according to the pitch of the tooth. (3) The Brown & Sharpe patent relieved tooth which is the same shape as the others except that alternate teeth are cut away on both sides at the top to one-half the width of the other teeth, and made 1/64 inch higher. This type of saw makes three small chips instead of one large one. (4) The Bryant type of tooth, which is used on saws of very heavy pitch, the saw being driven by a sprocket which engages the backs of the teeth. This type of tooth is ground about 1/32 inch thinner at the back than at the front, the purpose being to provide clearance for any burr which may be raised by the sprocket teeth. Examples of these different types of saw teeth are shown in Fig. 4.

Fig. 5. Nutter & Barnes Machine for Grinding V-type Circular Saw Teeth

The practice of cutting saw teeth on the gear-cutter is far superior to punching them, as the former method does not introduce any strains in the metal and insures the production of teeth of absolutely uniform pitch. In cutting the teeth of circular saws on a gear-cutting machine, the cutters are generally made of high-speed steel, 3½ inches diameter, thickness varying with pitch. The saw blanks are mounted upon an arbor and located in the proper relation to the cutter by means of an inside caliper. To explain this location of the work, suppose it is required to cut the teeth of a 14-inch circular saw with an arbor hole 1½ inch in diameter; the arbor on which the work is mounted would be located at $\frac{14 - 1\frac{1}{2}}{2} = 6\frac{1}{4}$ inches from the periphery of the cutter. The same method is used to determine the setting which will give the proper depth of tooth. In cutting teeth in high-speed steel saw blades, it is necessary to have a supporting plate at the back of the work to prevent the metal from breaking out at the back of the teeth; this plate has teeth cut in it similar to the teeth that are to be cut in the saw blade. After cutting the teeth, any burr which may remain on the saws is removed, and the saws are ready to be hardened.

Specially constructed heat-treating furnaces are used, and in conducting the heat-treating operation great care must be taken to see that the work is brought to a uniform temperature. Oil is the best fuel to use in the heating furnace, although gas can be employed with satisfactory results for temperatures up to 1800 degrees F. Saws made of low tungsten steel require a temperature varying from 1450 to 1800 degrees F. according to the character of the alloy and the nature of the quenching bath that is employed. High-speed steel saws are heated to from 1950 to 2250 degrees F. There are a number of different grades of quenching oils capable of giving satisfactory results; and where whale oil is used, beeswax, rosin and tallow are sometimes added to the contents of the quenching bath. Oil of degras, commonly known as "No. 2 soluble quenching oil," gives very good results, enabling the saws to hold their original shape very well. In hardening saws made of self-hardening steel, it is merely necessary to heat the blades to the required temperature and then clamp them between two heavy plates to prevent distortion while the metal is cooling. These plates are mounted on a hydraulic press and held together by a pressure of sixty pounds per square inch. The plates are water-cooled. Low tungsten steel saws are tempered in oil at from 350 to 475 degrees F.,

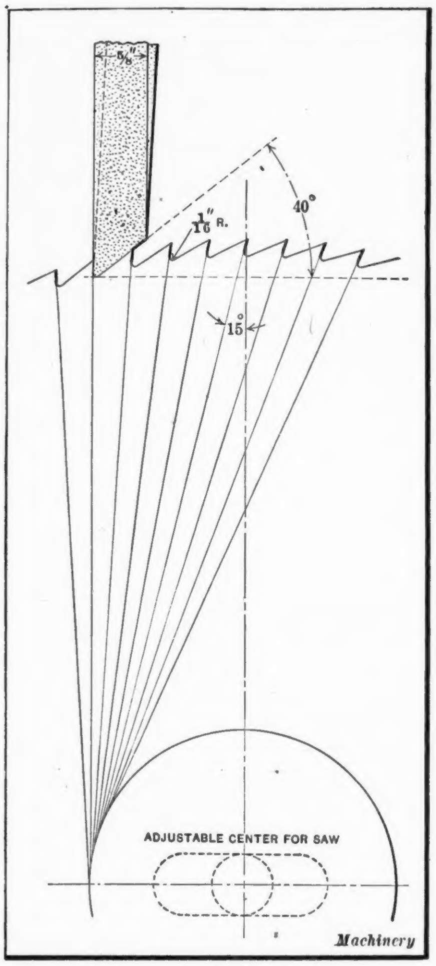


Fig. 6. Diagram showing Work done, Fig. 5

according to the nature of the alloy; and high-speed steel saws are drawn at temperatures ranging from 450 to 1200 degrees F. The idea of drawing the temper at 1200 degrees F. may frighten some people, but in the case of certain steels it will result in producing a tougher saw and one which is quite as hard as it would have been if the temperature had been drawn at 600 degrees F.

After tempering, the saws are again given to the sawsmith to be straightened, the work being done while the metal is still hot. It is very important for the saws to be fairly flat at the time that they leave the tempering furnace, as the work of straightening necessarily results in the introduction of strains in the metal. As already mentioned, a peening hammer is used in straightening the saw; this hammer is quite similar in shape to the hammer used for the previous straightening operation except that it has a sharper edge. It weighs 3½ pounds. After straightening, the arbor hole is ground to the correct size, a special vertical-spindle machine being used for this purpose; and hardened and ground gage plugs are used to determine the accuracy of its size. After the saw has been set up on the machine, the wheel-head is raised to bring the wheel into the working position; and an eccentric device governs the position of the wheel to provide for grinding the hole to the required size. Great annoyance and inconvenience have often been caused by not having the arbor hole true to size; if the hole is under size, it cannot be ground, and requires a great deal of time to "stone" it up to the required diameter. The exercise of some care in grinding will obviate much annoyance and the loss of a considerable amount of time in this way.

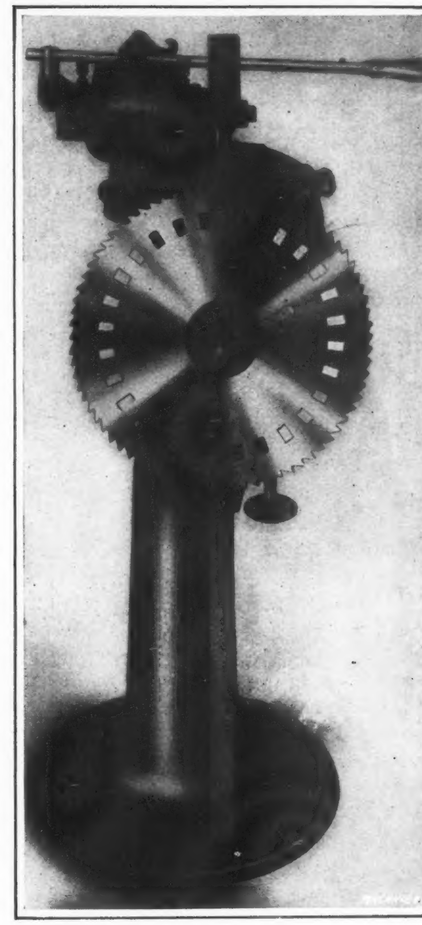


Fig. 7. Hunter Grinding Machine for "Land" Type of Circular Saw Teeth

The operation of so-called "straight" grinding, which consists of grinding the saw down to the required thickness, is done on a special double-wheel machine which provides for grinding both sides of the saw at the same time. The saw revolves on an arbor and is rotated by two driving wheels directly opposite the grinding wheels which travel in opposite directions, one grinding up and the other down. After being once more inspected by the sawsmiths, the saw blades are ready to be "taper" or hollow ground. The taper or clearance should be 0.025 to 0.035 inch for the first 2 inches in from the edge, and straight from that point to the collar. The saw is now mounted on a test mandrel and rotated to determine its true running qualities, after which it is ready to be sharpened. This is done on automatic machines equipped with very soft wheels, as the steel may easily be damaged by burning.

Sharpening circular saws with V-type teeth is a relatively simple matter. The saw blade is mounted on an arbor and the machine is furnished with a suitable index wheel for accurately spacing the teeth. A machine built by the Nutter & Barnes Co., Hinsdale, N. H., for doing this work is illustrated in Fig. 5, and Fig. 6 shows in diagrammatic form the conditions which must be fulfilled in grinding saw teeth of this type. It will be noticed that the position of the mandrel upon which the saw is mounted is adjustable to provide for obtaining the required under-cut for the face of the teeth. Fig. 7 illustrates a machine built by the Hunter Saw & Machine Co., Pittsburg, Pa., for grinding the tops of saw teeth of the "land" type; this is a hand-operated machine and its operation will be apparent to the reader after studying the illustration.

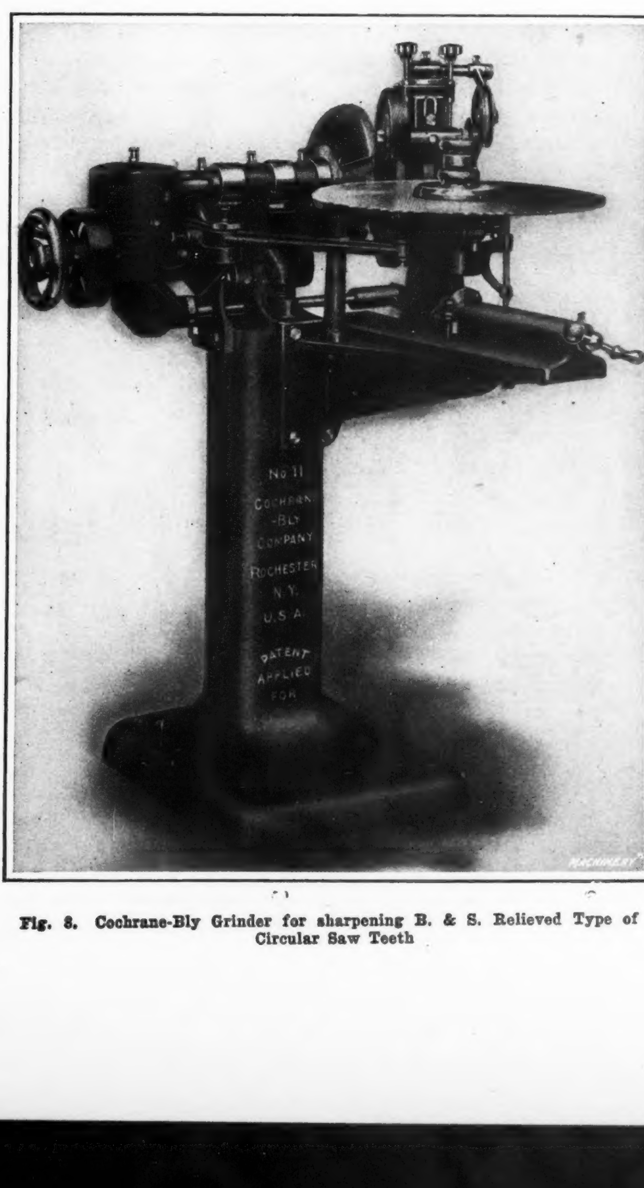


Fig. 8. Cochrane-Bly Grinder for sharpening B. & S. Relieved Type of Circular Saw Teeth

It will be obvious that the grinding of circular saws with the Brown & Sharpe relieved type of teeth calls for a more complicated form of machine than is needed for grinding the two types of teeth to which reference has been made. Fig. 8 shows a machine built for this purpose by the Cochrane-Bly Co., Rochester, N. Y. It is provided with three wheels and is automatic in its operation.

One wheel works in two directions, *i. e.*, forward and sideways; during the forward motion it grinds the front face of a tooth to an under-cut angle of 15 degrees, and during the side stroke it backs off the land at the top of the tooth to an angle of 5 degrees, leaving alternate teeth 1/64 inch higher than the teeth adjacent to them. This wheel is 8 inches in diameter and 40 grain, grade K; the forward and sidewise movements are controlled by cams.

The other two wheels on the machine are carried by a head that is mounted on a perpendicular slide. While the other wheel is grinding the faces and lands of two teeth, these wheels work on the under side of one tooth and the top of the next tooth but one, in order to reduce the thickness of alternate teeth to one-half the thickness of the full-width teeth. It is these narrow teeth which are left 1/64 inch higher than the full-width teeth. The wheels used for this work are about 4 inches in diameter, and 40 grain, grade O.

Fig. 9 shows in diagrammatical form the work done by the machine for grinding the Brown & Sharpe relieved type of saw teeth. It will be noticed that alternate teeth have either a full line or a dotted line across them, and these lines indicate the work done by the two wheels carried on the head mounted on a vertical slide; one of these wheels grinds the relief at the top of a tooth as indicated by the full line, and when the other wheel comes into action it grinds the relief at the bottom of the next alternate tooth that is shown by the dotted line. This idea will be understood by referring to the Brown & Sharpe relieved type of saw tooth shown in Fig. 4. Both wheels work on each alternate tooth in order to grind the relief at both sides, but the wheels do not work on the same tooth simultaneously. On the Cochrane & Bly machine the wheels grind on the same tooth at once, first the lower wheel and then the upper one.

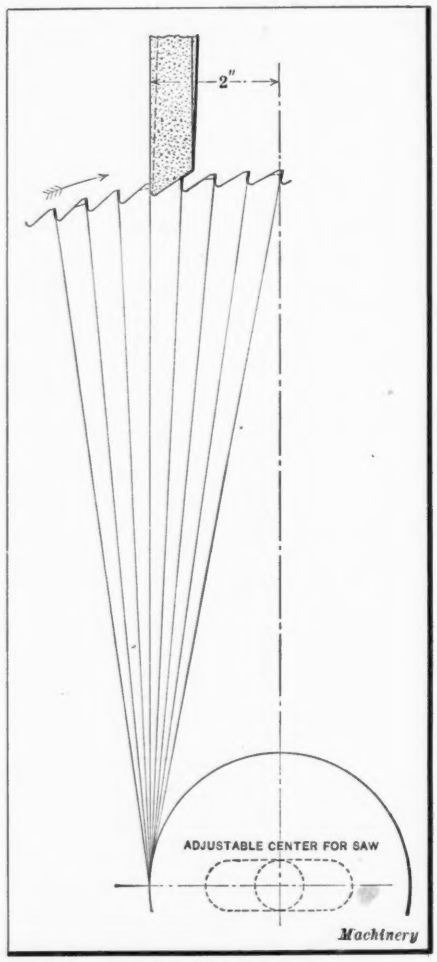


Fig. 9. Diagram showing Work done by Saw Tooth Grinder shown in Fig. 8

Polishing and etching are the last operations, the polishing being done with No. 40 Turkish emery. The etching requires considerable skill to secure satisfactory results, and although this does not affect the cutting qualities of the saw, it does have a great deal to do with the appearance of the product. The quickest and easiest method of etching saw blades is to use a rubber stamp covered with a thin film of acid, which is applied to the saw blade and allowed to remain for a sufficient length of time to eat into the metal. The trouble with this method is that it is difficult to secure clean-cut edges on the etched design, particularly when working on high-speed steel; and the acid also destroys the rubber stamps very rapidly. A more satisfactory method is to make a master plate in which is cut the legend and design that it is desired to etch on the saw blade. Transfers are made from this plate by first covering the plate with a paste made by boiling 3 pounds of beeswax and ½ cup of Venus turpentine, with sufficient spirits of turpentine to give the required thickness and enough lampblack to make the paste quite visible when it is spread on the master plate. After spreading it over the master plate, the surplus paste is wiped off, and a piece of tissue paper is then put over the plate and rolled down with a rubber roller. The tissue paper transfer is then lifted off and placed upon the saw in the position where the etching is to be done, and the paper is removed by moistening it with water. This leaves a coating of paste which forms the "resist" that protects the metal surrounding the design from the action of the acid used for etching. Shellac is also spread around the transfer to protect the saw from the acid. Nitric acid mixed with an equal volume of water is then applied over the transfer so that it will attack the portions of the steel which are exposed; and after being given a sufficient time to etch the metal, the surplus acid is neutralized by adding caustic potash solution. By this method very good results will be obtained. In etching high-speed steel it is desirable to add salt to the 50 per cent nitric acid solution. The saw is then entered on a record card system, of the form shown in Fig. 10, and sent to the shipping room. Heavy corrugated cardboards are placed between the saws when they are packed for shipment, to guard against the possibility of damage before they reach the customer's factory.

* * *

A manufacturer of mechanical specialties has devised a unique business card for representatives of the company in the form of a small two-sheet card folder, measuring 2 by 3 inches. This card, of medium weight stock, is of soft gray color and printed in a brown of harmonizing tone; it is arranged for use with the larger dimension vertically. The front sheet is cut with a circular opening near the top just the size of a cent, and an actual penny is affixed to the next sheet to show through; only the bright, new cent is used. Directly below, on the front sheet, is printed, "It's Worth A Penny To Know." On the second page, or reverse side of the front sheet, arrangement is made for indicating the name of the representative, while on the third page the company name, address, etc., is printed; this latter comes below the penny attached to this sheet and is covered by the front page of the card folder. The fourth, or outside back page, carries the company's trademark. This clever card arouses a natural interest and curiosity, and has been the means of obtaining many important interviews for the representatives, otherwise difficult to procure.

Our order No. 11476 Date: Oct. 16, 1915

Customer's order No. 6793

Name: John Adams

Address: Cincinnati, Ohio

Order received: Oct 13, 1915 Shipped: Oct. 17, 1915

Diameter: Inches	Thickness: Inch	No. of Teeth	Shape of Teeth	Type of Machine	Hardening Temperature: Degrees F.	Temper Drawn at Degrees F.	Steel	To Cut	No. of Saws Ordered	Remarks:
24	3/16	86	Undercut "land"	C.-B.	2250	1200	High speed	Machine steel bars 6 inches in diameter.	12	Cutting speed 40 feet per minute.

Machinery

Fig. 10. Form of Card used for keeping Record of Circular Saws

TUNGSTEN PRODUCTION IN THE UNITED STATES

The tungsten production in the United States during the first six months of 1916 was about 3290 short tons of concentrates carrying 60 per cent tungsten trioxide, according to a report made by the United States Geological Survey. The output of Colorado was 1505 tons, valued at $3,638,000, of which the Boulder field furnished 1494 tons. The tremendous rise of prices caused by the need of high-speed steel used in making war munitions ordered by the European governments caused the great increase in production. Ores carrying 60 per cent tungsten trioxide brought about $66 a unit at the beginning of the year. At first the sudden demand created by the orders for war steel was far ahead of the productive capacity of the country. The rapid rise in price starting last fall at a time when tungsten mining was at low ebb culminated in the undreamed maximum price mentioned. As a result, the production increased faster than the consumption, and soon overran the demand. By the end of June the price per unit of tungsten trioxide had fallen to $25. The normal price is between $6 and $7. The American production and imports of tungsten amount roughly to 5100 tons of 60 per cent concentrates, valued at $3,278,000. Allowing 20 per cent of the metal losses in various operations, it is estimated that between 11,000 and 12,000 tons of high-speed steels were made during the first six months of 1916, in addition to the steel made from tungsten saved from scrap.

Fig. 1. Shelby Steel Tubing after Bulging

* * *

BULGING SEAMLESS STEEL TUBING

A fine example of the manipulation which seamless steel tubing will stand without heating is illustrated in the accompanying halftone, Fig. 1. This shows a piece of Shelby steel tubing, the original diameter of which was 6 inches, and the walls ¼ inch in thickness. The dimensions of the bulged end are 6 inches in width by 9 inches in length, and the total amount of the bulging was done from one side of the tube.

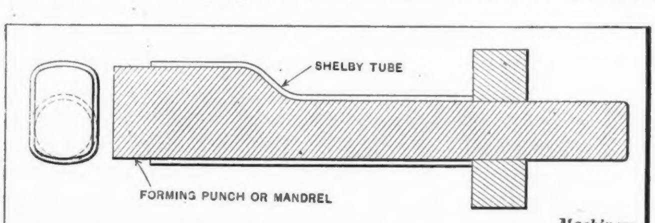


Fig. 2. Shelby Steel Tubing with Bulging Mandrel in Place

The manipulation of this tubing was done by James M. McClellon, of Everett, Mass., in connection with some experimental locomotive boilers he was building.

The work was done in a hydraulic wheel press such as is used in railroad shops for forcing wheels on the axles. Eighty-five-ton pressure was required. Aside from the fact that the tube was not heated for the operation, a remarkable feature of the operation was that the bulging was done without the use of a die. An inside form or punch of steel was made that started with a pilot 5½ inches diameter, and was formed exactly to the shape it was desired that the bulged tube should receive. This form was carefully smoothed up, coated with white lead, and forced into the tube, leaving it just as is shown in the photograph.

C. L. L.

* * *

THE ITEM OF WORKMANSHIP

The Bowman-Blackman Machine Tool Co., St. Louis, Mo., dealer in machine tools, steam hammers, electric cranes, etc., has issued a circular letter on the importance of workmanship, from which the following is taken:

To many people it is not clear why more money should be paid for one machine than for another that appears to have an equally meritorious design. Yet it is a fact that the builders who get the lion's share of the open, competitive machine tool business are the ones who make the high-priced tools. It is a fact that the steady buyers of tools almost invariably settle down to using the high priced lines, and one reason, as we see it, why the expensive makes give enough better satisfaction to warrant paying their extra cost is that they are better on the score of workmanship.

In our judgment, there is nothing that so much affects the performance of a tool, whether it be for fine tool-room work or for heavy, gruelling manufacturing operations, as the workmanship or the perfection of the fits. With two lathes, for instance, of exactly the same design, of which one was carefully fitted and the other carelessly, the difference in the performance would surprise one who had not had this feature previously impressed on him.

There is a great difference between a bearing that is merely snug and one that is a real fit. The former may touch in but a few spots and have but, say, a tenth of the full area of contact. It will thus wear out of alignment about ten times as quickly. It will pull harder, owing to the unequal oil film. It will chatter, because between the points of contact its members are unsupported or "overhanging." It will heat from the pressure from heavy cuts. From the standpoints of durability, power consumption, quality of output and amount of output, it will be seen that the point of workmanship in a machine is vital.

The final fitting is one of the most important items of expense in building high-grade tools. To illustrate its costliness, we mention that a prominent manufacturer of tool-room fixtures makes a difference in the price of surface plates, between those merely planed to a finish and those that are scraped to a fit, of almost double. In other words, the single final operation of perfecting the fit in this instance costs almost as much as the material and all the preliminary machine work combined.

* * *

MACHINE SHOP PRACTICE SESSION A.S.M.E.

H. K. Hathaway, chairman of the Committee on Machine Shop Practice, has prepared the following programme for the machine shop practice section of the American Society of Mechanical Engineers at the annual meeting in New York, December 5 to 8:

"Notes on the Standardization of Machine Tools," by Carl G. Barth;

"The Undoing of Established Mistakes," by Wilfred Lewis;

"A Classification of Machine Shop Practice and a Proposed Plan of Action for this Committee," by H. K. Hathaway.

Two sessions of the machine shop section will be held and an extended discussion of the papers is hoped for. The subject of machine tool standardization is most important, and it is expected that formal written discussions will be received from a number of well-known machine tool builders.

* * *

An unexpected result of workmen's compensation laws enacted in the various states has been the promotion of temperance. These laws are so drastic that the employer has often no defence in cases of gross negligence where the employe is solely to blame for getting hurt. Under these conditions no employer can take the risk of employing men addicted to drink, and many manufacturers in states having compensation laws have been active in promoting "no license." They also refuse to hire men who drink and discharge drinking men. The large steel mills have made it known that men can retain employment only on condition that they abstain from drinking anything stronger than "Adam's ale."

MACHINERY

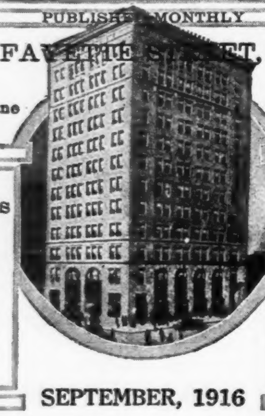
DESIGN—CONSTRUCTION—OPERATION

PUBLISHED MONTHLY

140-148 LAFAYETTE STREET, NEW YORK

England
51-52 Chancery Lane
London

Cable Addresses
Machinery, New York
Machtool, London



THE INDUSTRIAL PRESS
PUBLISHERS

ALEXANDER LUCHARS
PRESIDENT

MATTHEW J. O'NEILL
GENERAL MANAGER

ROBERT B. LUCHARS
SECRETARY

FRED E. ROGERS
EDITOR

ASSOCIATE EDITORS
ERIK OBERG
FRANKLIN D. JONES
DOUGLAS T. HAMILTON
CHESTER L. LUCAS
EDWARD K. HAMMOND
VICTOR BROOK

SEPTEMBER, 1916

NET CIRCULATION FOR AUGUST, 1916, 22,315 COPIES

EXPERIMENTAL ENGINEERING

While much has been said about the adverse influence of large corporations on the economic life and industrial development of the nation, it must be admitted that they have many redeeming features, one of which is the development of experimental engineering, possible only in a large organization. The development of any industry from an engineering standpoint will be comparatively slow and insignificant as long as the industry is carried on by organizations too small to maintain a costly experimental department; but when through combination or otherwise, a large industrial unit has been developed, it can afford the cost of a well-equipped experimental department, where a rapid development may take place. As an example may be mentioned the electrical industry in the United States, where remarkably rapid strides have been made in the development of new apparatus, new methods, and the discovery of new principles, mainly because the leading concerns in this field have been strong enough to spend large sums yearly on experimental work. One of them, for example, maintains a staff of hundreds of high-priced men, and has a large building of imposing dimensions set aside for nothing but experimental work. As a result of this work many new discoveries have been made, and new industries have been founded on the basis of these discoveries. While it is well known to engineers that in certain instances large corporations have retarded engineering progress by buying the patent rights and suppressing new inventions which have too seriously interfered with an industry they have already developed, it must be admitted that these instances are, in the case of some corporations, at least, more than compensated for by the opportunities for research and development made possible by their resources and facilities for experimental work.

* * *

INTENSIVE PRODUCTION

The scarcity of labor, high wages and high prices of materials will result in the adoption of much more efficient methods of production than now generally prevail. Machine tool making has been largely "building" rather than manufacturing. Lathes, planers, shapers, drilling machines and milling machines have been put through the shops in comparatively small lots and in a variety of sizes. There could be little of intensive methods of production employed, and costs were high. The big orders from Europe have made possible the manufacture exclusively of one size and kind of lathe, for instance, and some remarkable records have been made. One concern turned out 400 heavy simple turret lathes for projectile work, each weighing 10,000 pounds, in less than five months while carrying on its regular machine tool manufacture. But a separate plant was used for the special product and the most advanced methods of production were employed. Tools, jigs and fixtures were provided before starting work and every part was manufactured—not built.

Another "builder" of lathes has devoted his comparatively small plant exclusively to the manufacture of one size of engine lathe with astonishing increase of efficiency and capacity. When he was building several sizes of lathes and putting them through in lots, delays were common, due to some castings proving defective. A lot might be held up because two or three cone pulleys had developed blow-holes when machined. Time was required to get replacements from the foundry. But when building one size only, a few defective castings do not necessarily delay shipments, as the castings are ordered on a weekly supply basis and some of the incoming supply can be taken to fill out and the replacements used later.

* * *

MODERN FIXTURE DESIGN

The general conception of a jig is a holding means for guiding a drill when drilling machine parts so that every part will be drilled alike and no laying out will be necessary. A drill jig is necessarily light when designed for small parts, because it must be lifted and handled with the contained piece by the operator.

This general conception of the relation of a jig to the part has been mistakenly applied to work-holding fixtures for planers and milling machines. There is no need for lightness in a fixture for holding castings on a planer; instead there is need for great strength and rigidity. The parts must be adequately supported and firmly held if heavy cuts are to be taken. The same conditions apply with much greater force in milling. The pressure of hogging milling cutters is much greater than that of hogging planer tools. Fixtures used in the most progressive motor car plants for holding work on heavy milling machines are remarkable for weight and rigidity. A string of fixtures filling the length of the platen will in some cases weigh nearly as much as the platen itself.

The design of the fixtures is such that each casting is supported on compensating plugs, and while firmly gripped at a number of points, there is no distortion; the chucking is quickly accomplished without leveling up and the use of blocks, wedges, jacks and other common chucking accessories.

* * *

THE NEED OF SKILLED MEN

Never has there been so great a demand for machinists, machine operators and toolmakers as during the past and present year. The supply is far short of the demand, and manufacturers have been obliged to take in farmers, street-car conductors, bar-tenders, laborers and other likely men, and train them to become operators. This has been a costly and unsatisfactory process. Out of ten picked up from various other occupations, two or three may be found to have the natural skill and aptitude for mechanical work. The others have to be dismissed after they have received costly instruction and have spoiled much work. One concern estimates that it has cost from $200 to $300 per man to get one that was worth keeping.

The big makers of motor cars depend on the small concerns to train their help. They pay operators big wages during the season of heavy production and lay them off when business slackens. Such methods discourage the maintenance of apprentice systems by the concerns that realize the need of training skilled men. They cannot afford to train boys and have them taken away in the third or fourth years of their time when they are just beginning to repay some of the cost of the mechanical instruction given.

The evil has been serious for years, and seems to be getting worse instead of better. It is a big problem to be solved.

EDUCATIONAL PREPAREDNESS VS. INDUSTRIAL PROGRESS

W. H. DOOLING*

The vast armies and navies of Europe at the present day, together with their enormous equipments and resources, are leading to campaigns of military preparedness on the part of this nation. The conclusion has been reached that if we are to keep pace with the rest of the mighty world powers, we must be prepared to meet them on a military as well as on a peace basis. Army and navy experts are urging larger expenditures of money for greater fighting forces and equipment. The enormous sums spent in waging war are not productive of any wealth to the country. If such large sums of money could be obtained and expended in the furtherance of industrial education, the wealth and prosperity of the nation would be materially increased. The National Association of Manufacturers, in 1912, estimated the annual national loss in human resources, due to 50 per cent of the children leaving school in the elementary grades, at $250,000,000. A consideration of these figures leads us to the conclusion that a campaign of educational preparedness should be waged no less vigorously than one of military preparedness, in order that these losses may be made up and the wealth and prosperity of the nation increased.

Of late years education and industry have been forced to recognize their close relation to each other. The phenomenal progress of industry has clearly outstripped the feeble efforts that education has put forth to meet it, and, as a result, we have such losses as cited above. It is interesting to note the slow progress of education in contrast to that of industry. Not so many years ago the secondary schools of our country had but one aim in view—to prepare students for higher institutions where they would take up one of the professions, law, medicine or the ministry. Of the small percentage of grammar school graduates who entered high school, a still smaller percentage were annually graduated. Only a select few could then enter college, and there they pursued still further their classical studies leading to one of the recognized professions.

Meanwhile the rise of modern industry had begun. The old apprenticeship system had fallen into disuse. Times had changed since the shoemaker made the entire shoe and cloth was manufactured in the home. The invention of shoemaking machinery, the power-loom, the cotton gin, power-harvester, etc., called for a division of labor, and a great industrial change took place. Large concerns grew up; large numbers of employes were needed; a great demand for managers and superintendents arose; and these people needed an education. Young men were needed in the shops, yet the employers had no time, nor could they afford to teach them the trade thoroughly, but simply gave them one certain thing to do. In other words, these boys became mere cogs in the wheels of industry. Here again education in the schools ought to have been able to teach these young men the theory and practice of the trades, and make them more valuable to their employers.

But education was unprepared; it went ahead with its classical curricula, ignoring the needs of its communities, training the smaller proportion of the pupils to the exclusion of the larger. After a long search for competent men on the part of employers, they thought that possibly in the large amount of material scrapped annually from the schools there might be some which under proper treatment would prove valuable. Many pupils who had no ability for book learning were found to have considerable manual dexterity, coupled with a certain ability to think and think well about mechanical subjects. After much opposition, a few courses relating to the trades were adopted by some high schools. Later, high schools and schools devoted exclusively to technical education were founded. At present we have the manual training, technical and trade schools, offering a variety of courses to meet the needs of this class of pupils. In some schools part-time courses are in use, whereby the pupil is enabled to spend part of his time in the shop and part of his time in school, thus combining theory with actual shop practice. A gratifying percentage of the scrap heap has been reclaimed. These pupils are doing good work for their employers and for themselves.

* Address: 38 Cane St., Fitchburg, Mass.

But there is still a great deal to be done. In order that education may be prepared and that the schools may be as efficient as possible in their teaching of technical subjects, it is of utmost importance that they have the hearty cooperation of the manufacturers and employers themselves. Their good will is not enough; there must be active participation of some sort in order that the best results may be obtained. The boys in school are very likely to think that there is a wide gulf separating them from the actual industry they contemplate entering. This does not mean that a man must break up his shop organization. If he could spare an hour or two once in awhile to give a talk at the school, it would do wonders toward bridging this gulf. He might present to them the problems that are coming up daily in his line of work. This would help to keep both instructor and pupil in touch with everyday conditions and also stimulate their inventiveness. Or, if a manufacturer is unable to spare the time, he might encourage visits to his shop or factory on the part of the pupils, and delegate a subordinate to point out and explain the different processes and machines. When he is sending out catalogues, he might remember to address a few to the school of his community, for these catalogues are of prime interest to the trade student. These few suggestions may, of course, be supplemented by others which will occur to the employer, if he endeavors to help along the school of his community.

In this way he will be helping himself by building up better material from which to choose his subordinates, and helping the great mass of children who up to this time have been handicapped in the struggle for existence by a lack of training. Hearty and active cooperation of manufacturers and schools will aid education to prepare for its proper work—to realize its highest ideals, namely, the preparation of *all* children for earning an honest livelihood in the trade for which they are by nature and training best fitted.

* * *

CENSUS OF MANUFACTURES IN THE UNITED STATES

A preliminary statement of the general results of the census of manufactures for the United States, issued by Director Sam. L. Rogers of the Bureau of the Census, consists of a summary comparing the figures for 1909 and 1914, by totals. The figures are preliminary and subject to such change and correction as may be found necessary from a further examination of the original reports. The census of 1914 excluded the hand trades, the building trades, and the neighborhood industries, and took account only of establishments conducted under the factory system. Statistics were not collected for establishments having products valued at less than $500.

Compared with the manufactures census of 1909, the capital invested increased 23.7 per cent, or from $18,428,270,000 to $22,790,880,000. The number of establishments increased from 268,491 to 275,793, or 2.7 per cent; the average capital per establishment increased from $69,000 to $83,000. The value of the products increased 17.3 per cent, or from $20,672,052,000 to $24,246,323,000; the average value per establishment was $88,000, an increase of $11,000. The number of persons engaged in manufactures increased 7.6 per cent, or from 7,678,578 to 8,265,426, but the number of proprietors and firm members decreased 3.1 per cent, or from 273,265 to 264,872. The number of salaried employes, however, increased 22 per cent, or from 790,267 to 964,217. The amount paid in salaries increased 37.2 per cent, or from $938,575,000 to $1,287,917,000; an average increase of about $150 a year to each employe. The number of wage earners increased from 6,615,046 to 7,036,337, or 6.4 per cent. The amount paid in wages increased from $3,427,038,000 to $4,079,332,000, an average increase of about $70 a year to each one. In 1914, the greatest number were employed during March and April, and the smallest number in December and November; in 1909 the greatest number were employed in November and December, and the smallest number in January and February. The primary horsepower used, in 1914, increased 20.7 per cent, or from 18,675,376, in 1909, to 22,537,129, and the value added by the manufacture (the value of the products less the cost of materials) increased 15.8 per cent, or from $8,529,261,000 to $9,878,234,000.

SNAPSHOTS ON THE ROAD

ONE WAY TO HIRE MEN—WHEN LUBRICATION WORKED TOO WELL—SOME COMPETITION—CURING THE LATHE THAT WOULDN'T TURN STRAIGHT—A DIFFICULT MILLING JOB—THE UNKNOWN PLANT

BY THE FIELD EDITOR

"SIT down here a minute, Mr. Field Editor, I want to show you the most exacting inquiry that ever came into this office," said the manager of a gear-cutting shop. And as I settled into my chair, the manager went through his files and pulled out an inquiry from a person in Central Pennsylvania. The inquirer stated that he was in the market for gears for special apparatus that he was designing, and he desired gears cut that would turn two cylinders, one large and one small, at such rates that their peripheral travel would be coincident. So far the inquiry was ordinary, but this critical inventor went on to state that the diameter of the large cylinder, *as nearly as he could measure it*, was 1.765633739 inch and the circumference was 5.5469 inches. The small cylinder, he wrote, was 0.5625 inch in diameter, and 1.767175 inch in circumference.


"And asked how many fellows wanted jobs at $5 a day"

"Say," chuckled the manager, "it's mighty lucky for us that that chap couldn't measure any closer!"

One Way to Hire Men

In traveling around the country you hear of all kinds of methods of hiring skilled mechanics, especially in these times when men are scarcer than the proverbial hen's teeth; but I had a "new one" called to my attention by the superintendent of a shop in Southern Connecticut that is near a mammoth arms plant noted for its aggressiveness in securing men.

"It sure was funny," said the superintendent. "That big octopus plant has been scouring the country for men and getting some good ones, too, by paying the highest wages. The employment director got a brilliant idea. He thought that some of the toolmakers he had pulled from country shops and who went back to their homes every week-end could be induced to bring down more of their former shopmates. So that Saturday morning he tried his plan on a man whom he had purloined from a shop in Western Massachusetts."

"And how did the stunt work?"

"Oh, the stunt worked all right," chuckled the superintendent. "The toolmaker came back Monday morning and reported that he had six of his former shopmates down in the employment line waiting their turn to fill out the blanks. But the morning passed away without the men arriving in the shop, and the employment manager questioned the 'procurer,' who was dumbfounded to think that his friends had not shown up, because he had personally placed them in the line. Well, that night the man went to his boarding house and found his former shopmates all sitting there as unconcerned as could be. The explanation was simple. 'We were standing in the line waiting our turn,' one of the men explained, 'when an automobile stopped in front of the line and a dandy looking chap with a fur overcoat stepped out and asked how many fellows wanted jobs at $5 a day. We six chaps were sticking together, so we immediately jumped into his machine, and he took us down to his shop, and we landed some fine jobs, too.'"

It was certainly a new way to get men and, though questionable, was more direct than the equally questionable method that the big company had employed to get its men.

When Lubrication Worked Too Well

"Say," said the superintendent, "did you ever hear of a lubricant that did its job too well?"

"No," said I, settling back in the visitor's chair beside the superintendent's desk; "I certainly didn't suppose there was such a thing as over-lubrication."

"Well, just turn around and look at the job on that big horizontal boring mill out there, and you'll understand my story better."

Following the superintendent's glance, I saw the horizontal boring mill, and two laborers were tugging at a big fixture on the table, presumably to turn it so as to line it up for some particular hole to be bored.

"That fixture," said the superintendent, "weighs 2000 pounds, and the casting weighs another 800 pounds. You can appreciate that it is a real man's job—or rather two men's job—to turn that fixture every time it is necessary to reset it for boring a new set of holes. You'll notice that it's a box fixture, so that perfect alignment is not necessary, as a universal joint connects the machine spindle with the boring-bar, but nevertheless it must be turned after every pair of holes.

"I sat here one afternoon looking out, just as we are now, watching those two laborers turn that fixture, and it occurred to me that a little graphite and oil smeared on the base would make it turn a whole lot easier, so we tried it out, and sure enough it could be turned by one man very easily. I came back and sat down and congratulated myself that there was another job well taken care of, but I had no more than got comfortably started on a long report on "Why the Shop Overhead Has Increased" when Tom, the boring mill hand, came into the office with the funniest look on his face and said, 'I can't make that darned fixture stay put anywhere, even when I set those clamps up with all my strength. That fixture just seems to slip and slide all over the lot when the cut starts.'

"And Tom was right. I went out there and he hadn't overstated the case at all. That graphite had done its work so well that it was impossible to get any adhesion between the fixture and the boring mill bed, and nothing remained for us to do but clean off the graphite and use the fixture in the same old way. It's a strange thing, but this seems to be a case where elbow grease works better than graphite."

Some Competition

The problems encountered in a job machine shop often form the subjects of interesting discussions. I was visiting a shop in a fair sized country town, and the job shop man was telling how he had lost a contract for turning shafts.

"The other fellow beat me to it on price by about 50 per cent, and naturally he got the job," said the shop man.

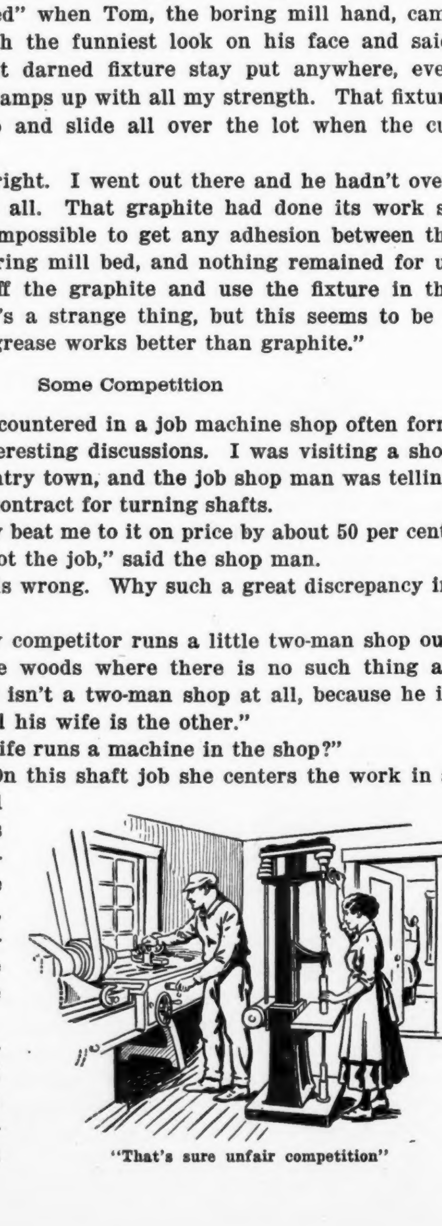
"But something is wrong. Why such a great discrepancy in the two bids?"

"That's easy; my competitor runs a little two-man shop out on the edge of the woods where there is no such thing as rent; and it really isn't a two-man shop at all, because he is one of the men and his wife is the other."

"You mean his wife runs a machine in the shop?"

"Exactly that. On this shaft job she centers the work in a drill press and drills a few cross holes in the finished work and he runs a lathe. So, everything considered, you can see how he can figure pretty close."

"That's sure unfair competition," I said, rising to leave; but that chap's going to lose out


"That's sure unfair competition"

"All of which goes to show what a little misplaced matter will do"

somehow and sometime just as sure as I'm a foot high—because he has the wrong business viewpoint.

Curing the Lathe that Wouldn't Turn Straight

Many a good story comes from the chair of a hotel lobby long after factory wheels have stopped turning. There was a good lesson in the one told by old George Watson, the veteran salesman for a large lathe manufacturing company.

"It happened down in the oil country where I was setting up half a dozen lathes in one of those old Pennsylvania shops that were built before the war. I had one lathe set up and the operator was doing nicely, so I started out to line up another. About the middle of the afternoon the operator of the first machine came to me and said, 'Would you believe it, Mr. Watson, my lathe that you lined up so nicely has been turning as straight as a die up to fifteen minutes ago, but now I can't get a straight cut off the darned thing. Come over and see what's the matter.'

"I went over, and sure enough you couldn't make that lathe cut straight to save your life, but I *knew* it had been right all the morning, so I stood off to one side and looked for the answer. And I found it. Over at the back of that lathe near one corner was a truck loaded with as many rough iron shafts as could be piled on it. The helper had left this standing there a half hour ago, and the load was too much for that old floor, so when it sagged, the corner of the lathe went with it. I told them to pull that truck out of 'speaking' distance, and the lathe came back into line and turned just as prettily as you could expect any well behaved lathe to do."

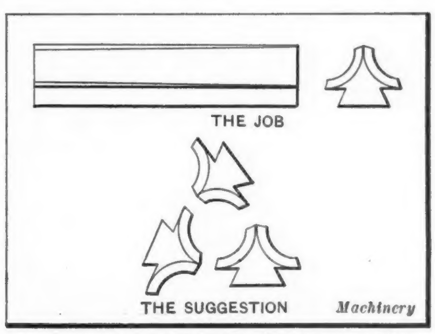
All of which goes to show what a little misplaced matter will do.

A Difficult Milling Job

"I have asked every mechanical man who has been here in the last two weeks what his ideas would be about tackling a milling job that I have on the slate," said the master mechanic, after having finished a circuit of the shop. "You see, the proposition is this. I have these machine steel forgings furnished me and they must be milled all over," and he rapidly drew a little sketch on his pad.

"It would be a nice little job except for the fact that the radius of the milled section tapers from one end to the other. And this prevents me from making the two cuts with a pair of straddle-milling cutters. After asking everyone I can think of, I have decided to make a cutter the full length of the work, with bearings as large and long as possible, and feed the work broadside into the cutter. Then I'm going to skip over to the other side and make the same cut, and finish that side also. I don't like the idea of running that small diameter cutter up there broadside, but I don't see any other way, do you?"

"It seems to me," said I, taking out my pencil, "I'd tackle that job something like this: I'd have a pair of fixtures and load three of the parts around each fixture so that the parts to be milled would be around a circle of the right diameter. Then with a cutter on the lines of a taper reamer, having a long piloted bearing, I'd take a cut endwise right through the work up to a stop, and get three pieces for every pass of the cutter instead of one. I haven't attempted to draw up the fixture, but you can see how the work should be spaced, and any of your men can get up a suitable fixture."



"It seems to me I'd tackle that job something like this"

"By George," said the master mechanic, "I never thought of that; and I'll tell you right now that if the fixtures that are partly made don't work, I'm going to try out your idea. Come in again where you're along this way. We'll always be glad to see you."

"Quality First"

"See that sign," said the president of one of the best known precision tool companies of the country. "Look around the shop and you'll see these 'Quality First' signs posted everywhere. It's a motto we want to instill in the minds of every man connected with this organization, from the sweeper up. The first requirement in our work is quality. Quantity always comes second, and only by hammering this home in every way we can think of can we keep our men in the right frame of mind for accurate work."

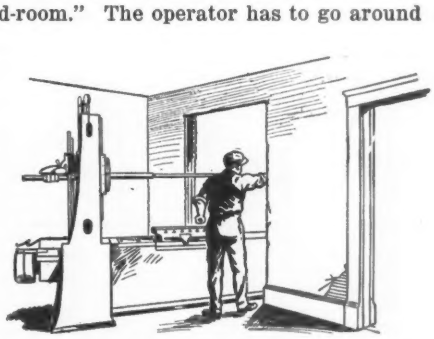
And the manager was right. Whether it was in the grinding room, the lathe department, the planning department or the shipping room, there was a sign reading "Quality First."

The Unknown Plant

Lying close to a railroad track in a Middle Western town is a plant of a prominent manufacturer making a special line of machinery. The machinery is well-known, but the visitor could not find the factory without inquiring of practically everyone he met on the street. No name adorns this prominent plant, and after chasing through a number of back yards, over fences, railroad tracks, through kitchens, etc., you finally land in front of an unpretentious building called the office. Even the shape of the building does not indicate that it is used for a manufacturing office. But upon opening the door a safe is detected and the name of the manufacturer is at last learned.

The first impression of carelessness holds good; when you once find the office, you are shown the manager, who has to take great care in rising from his chair in order not to disturb two years' correspondence packed on his desk. One corner of his desk is piled a foot high with telegrams—some of them at least three years old. Letters, pieces of machinery—parts long since forgotten—and ink-wells of all sizes and descriptions clutter the remaining space. The pigeon holes in the desk are also filled to overflowing, and look as though they had not been cleaned out since the incumbent started in business.

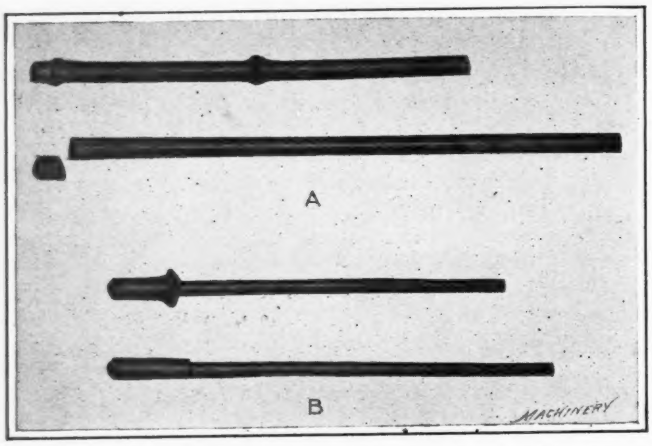
Again first impressions are borne out when you are shown into the shop. How a manufacturer can turn out accurate machinery in such a plant is almost inconceivable. The plant probably has grown. Yes, it has. It has been in business for at least twelve to twenty years, and in that time surely should have grown some. But in growing it has taken in existing buildings and made use of kitchens, sheds, bed-rooms, etc. No care has been taken to see that the floors of the various rooms have been leveled up or that the partitions have been torn down. For instance, you will find a boring machine having its cutting end working in the "dining-room" and its driving end in the "bed-room." The operator has to go around a partition to change his gears! Such conditions make anything but a favorable impression upon the visitor to this shop. But then—if it suits the owner, I suppose it is his business to run his plant as he sees fit; but is it *good* business?



"You will find a boring machine with its cutting end working in the dining-room and its driving end in the bed-room"

UNUSUAL ELECTRIC BUTT-WELDING

At *A* in the illustration is shown a ½-inch diameter steel rod which is approximately sixteen inches long and a short ½-inch diameter brass rod which is about one inch long. Above this is shown the pin completely welded. This is known



Interesting Examples of Butt-welding

as a "kicking-pin" which is used in a textile drying machine. To complete one of these kicking-pins, two operations are necessary.

The first operation consists in grasping the center of the ½-inch steel rod in the clamping electrodes of a Thomson electric welder. The electrodes are clamped on this rod a predetermined distance apart, and the current is turned on. After the central portion of the rod is heated by electrical resistance to a white heat, the electrodes are moved toward each other a certain distance which forms in the middle of the rod a very symmetrical shoulder as shown. A second operation on this piece consists of welding the short brass rod to the end of the long steel rod. This operation is accomplished without any difficulty, although not without a large burr being thrown up all around. This burr is subsequently ground off, revealing a very good joint between the brass and steel rods.

At *B* are shown two rods before and after being welded together. The unusual thing about this operation is that the two rods are of such different diameters. The shorter one which is approximately ½ inch in diameter is made of tool steel, and the longer one which is about 9/32 inch in diameter is made of cold-rolled steel. Each of these rods is held in an electrode clamp, and upon being brought together they get very hot, the smaller rod heating much faster than the larger rod because of its smaller cross-section. Owing to its tendency to heat faster, the small rod, when pressure is brought to bear upon it, quickly flattens out on the end to such an extent that the flattened portion has as large a cross-section as the short rod. When this stage has been reached the rods are separated for a short time, and immediately the temperature of the smaller rod drops to very nearly that of the larger one. When these rods have reached the same temperature, they are again brought together and, because of the fact that the cross-sections are now approximately the same on the ends of both rods, the tendency is for both rods to heat uniformly, thereby causing a perfectly good electric weld. This operation also throws up a large burr which is removed by grinding.

* * *

A few years ago there was a strong feeling in this country that the most important element in any enterprise was the financial element, and that if there was only money enough available nothing else mattered much. This idea has not held good, for we are beginning to realize that there is an end to the largest bank account, and are rapidly coming to the conclusion that neither money nor organization will permanently insure success without proper direction. It is therefore imperative for us to study leadership and to find the laws on which successful administration is based.—*H. L. Gantt, in Industrial Leadership.*

CIRCULAR FORMING TOOLS FOR NO. 6 B. & S. SCREW MACHINE*

BY WILLIAM W. JOHNSON†

When a large number of circular forming tools are to be designed, a great deal of labor is involved in computing the different diameters separately. The usual method is as follows (see diagram):

First, find the value of W in the right angle triangle ACD.

$$W = \sqrt{r^2 - h^2}$$

in which

r = radius of largest diameter of circular tool;

h = distance to which the center of the tool is set, either above or below the center line of the work.

Now, find the value of r in the right angle triangle ACD.

$$r = \sqrt{(W - c)^2 + h^2}$$

in which

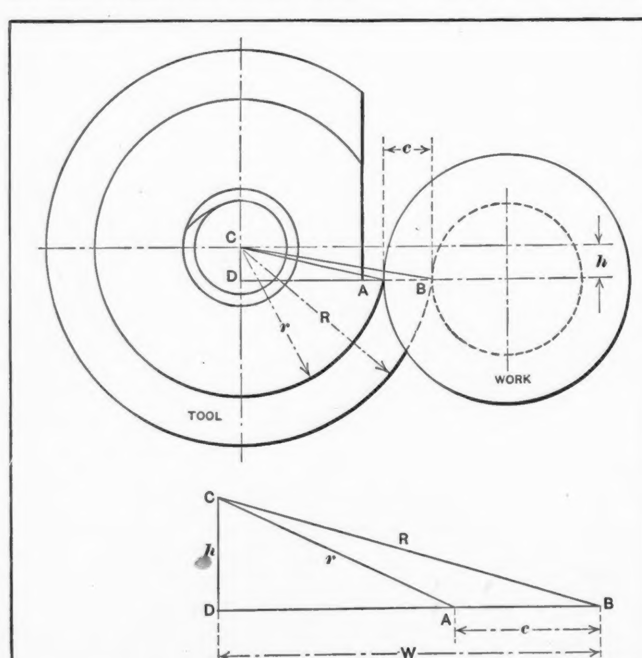
c = one-half the distance between the required diameters of the work;

r = the required radius of the circular tool.

This method is quite long and cannot be materially shortened by using a table of squares. Therefore, anything that can be done to aid in computing the different diameters of circular forming tools will be of interest. This article will give a series of tables which have been computed for the diameters of circular tools, corresponding to variations of one-thousandth inch in the radius of the work. These tables are applicable to the new No. 6 Brown & Sharpe automatic screw machine, the general dimensions of which are given below.

Maximum Diameter of Tool—D	= 4
Center of Tool Above Center of Work—h	= 5/16
Tap, Left-hand	= 3/4 — 12 pitch
W	= 3/8

The maximum diameter D of forming tools for this machine should be 4 inches. To find the other diameters of the tool for any piece to be formed, proceed as follows: Subtract the smallest diameter of the work from the diameter of the work which is to be formed by the required tool diameter; divide the remainder by two; locate the quotient obtained in the column headed "Length c on Tool," and opposite the figure thus located and in the adjacent column read off directly



Notation used in Formulas for Forming Tool Calculations

the diameter to which the tool is to be made. The quotient obtained which is located in the column headed "Length c on Tool," is the length c as shown.

* For previous articles relating to circular forming tools, published in MACHINERY, see also "Calculation of Circular Forming Tools," March, 1911; "Circular Form and Cut-off Tools," March and April, 1910; "Formulas for Circular Forming Tools," January, 1908; "Charts for Forming Tools," October, 1904; "Straight and Circular Forming Tools," June, 1904.

† Address: 12013 Saywell Ave., Cleveland, Ohio.

DIMENSIONS OF CIRCULAR FORMING TOOLS FOR NO. 6 B. & S. AUTOMATIC SCREW MACHINE

Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool
0.001	3.9980	0.081	3.8401	0.162	3.6803	0.242	3.5228	0.323	3.3635	0.404	3.2045	0.484	3.0477
0.002	3.9960	0.082	3.8381	0.163	3.6784	0.243	3.5208	0.324	3.3615	0.405	3.2025	31/64	3.0470
0.003	3.9940	0.083	3.8361	0.164	3.6764	0.244	3.5188	0.325	3.3596	0.406	3.2006	0.485	3.0457
0.004	3.9921	0.084	3.8342	0.165	3.6744	0.245	3.5169	0.326	3.3576	13/32	3.2001	0.486	3.0438
0.005	3.9901	0.085	3.8322	0.166	3.6724	0.246	3.5149	0.327	3.3556	0.407	3.1986	0.487	3.0418
0.006	3.9881	0.086	3.8302	0.167	3.6705	0.247	3.5129	0.328	3.3537	0.408	3.1966	0.488	3.0398
0.007	3.9862	0.087	3.8282	0.168	3.6685	0.248	3.5110	21/64	3.3534	0.409	3.1947	0.489	3.0379
0.008	3.9842	0.088	3.8263	0.169	3.6665	0.249	3.5090	0.329	3.3517	0.410	3.1927	0.490	3.0359
0.009	3.9822	0.089	3.8243	0.170	3.6646	0.250	3.5070	0.330	3.3498	0.411	3.1908	0.491	3.0340
0.010	3.9802	0.090	3.8223	0.171	3.6626	0.251	3.5051	0.331	3.3478	0.412	3.1888	0.492	3.0320
0.011	3.9783	0.091	3.8203	11/64	3.6609	0.252	3.5031	0.332	3.3458	0.413	3.1868	0.493	3.0300
0.012	3.9763	0.092	3.8184	0.172	3.6606	0.253	3.5011	0.333	3.3439	0.414	3.1849	0.494	3.0281
0.013	3.9743	0.093	3.8164	0.173	3.6586	0.254	3.4992	0.334	3.3419	0.415	3.1829	0.495	3.0261
0.014	3.9723	3/32	3.8149	0.174	3.6567	0.255	3.4972	0.335	3.3399	0.416	3.1810	0.496	3.0242
0.015	3.9704	0.094	3.8144	0.175	3.6547	0.256	3.4952	0.336	3.3380	0.417	3.1790	0.497	3.0222
1/64	3.9692	0.095	3.8124	0.176	3.6527	0.257	3.4933	0.337	3.3360	0.418	3.1770	0.498	3.0202
0.016	3.9684	0.096	3.8105	0.177	3.6508	0.258	3.4913	0.338	3.3341	0.419	3.1751	0.499	3.0183
0.017	3.9664	0.097	3.8085	0.178	3.6488	0.259	3.4893	0.339	3.3321	0.420	3.1731	0.500	3.0163
0.018	3.9644	0.098	3.8065	0.179	3.6468	0.260	3.4874	0.340	3.3301	0.421	3.1712	0.501	3.0143
0.019	3.9625	0.099	3.8045	0.180	3.6449	0.261	3.4854	0.341	3.3282	27/64	3.1695	0.502	3.0124
0.020	3.9605	0.100	3.8026	0.181	3.6429	0.262	3.4834	0.342	3.3262	0.422	3.1692	0.503	3.0104
0.021	3.9585	0.101	3.8006	0.182	3.6409	0.263	3.4814	0.343	3.3242	0.423	3.1672	0.504	3.0085
0.022	3.9565	0.102	3.7986	0.183	3.6389	0.264	3.4795	11/32	3.3227	0.424	3.1653	0.505	3.0065
0.023	3.9546	0.103	3.7966	0.184	3.6370	0.265	3.4775	0.344	3.3223	0.425	3.1633	0.506	3.0046
0.024	3.9526	0.104	3.7946	0.185	3.6350	17/64	3.4763	0.345	3.3203	0.426	3.1614	0.507	3.0026
0.025	3.9506	0.105	3.7927	0.186	3.6330	0.266	3.4755	0.346	3.3184	0.427	3.1594	0.508	3.0006
0.026	3.9486	0.106	3.7907	0.187	3.6311	0.267	3.4736	0.347	3.3164	0.428	3.1574	0.509	2.9987
0.027	3.9467	0.107	3.7887	3/16	3.6301	0.268	3.4716	0.348	3.3144	0.429	3.1555	0.510	2.9967
0.028	3.9447	0.108	3.7868	0.188	3.6291	0.269	3.4696	0.349	3.3125	0.430	3.1535	0.511	2.9948
0.029	3.9427	0.109	3.7848	0.189	3.6271	0.270	3.4677	0.350	3.3105	0.431	3.1516	0.512	2.9928
0.030	3.9408	7/64	3.7841	0.190	3.6251	0.271	3.4657	0.351	3.3085	0.432	3.1496	0.513	2.9909
0.031	3.9388	0.110	3.7828	0.191	3.6232	0.272	3.4637	0.352	3.3066	0.433	3.1476	0.514	2.9889
1/32	3.9383	0.111	3.7808	0.192	3.6212	0.273	3.4618	0.353	3.3046	0.434	3.1457	0.515	2.9870
0.032	3.9368	0.112	3.7789	0.193	3.6192	0.274	3.4598	0.354	3.3026	0.435	3.1437	33/64	2.9858
0.033	3.9348	0.113	3.7769	0.194	3.6173	0.275	3.4578	0.355	3.3007	0.436	3.1418	0.516	2.9850
0.034	3.9329	0.114	3.7749	0.195	3.6153	0.276	3.4559	0.356	3.2987	0.437	3.1398	0.517	2.9831
0.035	3.9309	0.115	3.7730	0.196	3.6133	0.277	3.4539	0.357	3.2968	7/16	3.1388	0.518	2.9811
0.036	3.9289	0.116	3.7710	0.197	3.6113	0.278	3.4519	0.358	3.2948	0.438	3.1378	0.519	2.9792
0.037	3.9269	0.117	3.7690	0.198	3.6094	0.279	3.4500	0.359	3.2928	0.439	3.1359	0.520	2.9772
0.038	3.9250	0.118	3.7671	0.199	3.6074	0.280	3.4480	23/64	3.2921	0.440	3.1339	0.521	2.9753
0.039	3.9230	0.119	3.7651	0.200	3.6054	0.281	3.4460	0.360	3.2909	0.441	3.1320	0.522	2.9733
0.040	3.9210	0.120	3.7631	0.201	3.6035	9/32	3.4455	0.361	3.2889	0.442	3.1300	0.523	2.9714
0.041	3.9190	0.121	3.7611	0.202	3.6015	0.282	3.4441	0.362	3.2869	0.443	3.1280	0.524	2.9694
0.042	3.9171	0.122	3.7592	0.203	3.5995	0.283	3.4421	0.363	3.2850	0.444	3.1261	0.525	2.9674
0.043	3.9151	0.123	3.7572	13/64	3.5993	0.284	3.4401	0.364	3.2830	0.445	3.1241	0.526	2.9655
0.044	3.9131	0.124	3.7552	0.204	3.5976	0.285	3.4382	0.365	3.2811	0.446	3.1222	0.527	2.9635
0.045	3.9111	0.125	3.7533	0.205	3.5956	0.286	3.4362	0.366	3.2791	0.447	3.1202	0.528	2.9616
0.046	3.9092	0.126	3.7513	0.206	3.5936	0.287	3.4342	0.367	3.2771	0.448	3.1182	0.529	2.9596
3/64	3.9075	0.127	3.1493	0.207	3.5917	0.288	3.4322	0.368	3.2752	0.449	3.1163	0.530	2.9577
0.047	3.9072	0.128	3.7473	0.208	3.5897	0.289	3.4303	0.369	3.2732	0.450	3.1143	0.531	2.9557
0.048	3.9052	0.129	3.7454	0.209	3.5877	0.290	3.4283	0.370	3.2712	0.451	3.1124	17/32	2.9552
0.049	3.9032	0.130	3.7434	0.210	3.5858	0.291	3.4263	0.371	2.2693	0.452	3.1104	0.532	2.9538
0.050	3.9013	0.131	3.7414	0.211	3.5838	0.292	3.4244	0.372	3.2673	0.453	3.1084	0.533	2.9518
0.051	3.8993	0.132	3.7395	0.212	3.5818	0.293	3.4224	0.373	3.2654	29/64	3.1081	0.534	2.9499
0.052	3.8973	0.133	3.7375	0.213	3.5798	0.294	3.4204	0.374	3.2634	0.454	3.1065	0.535	2.9479
0.053	3.8953	0.134	3.7355	0.214	3.5779	0.295	3.4185	0.375	3.2614	0.455	3.1045	0.536	2.9460
0.054	3.8934	0.135	3.7335	0.215	3.5759	0.296	3.4165	0.376	3.2595	0.456	3.1026	0.537	2.9440
0.055	3.8914	0.136	3.7316	0.216	3.5739	19/64	3.4148	0.377	3.2575	0.457	3.1006	0.538	2.9421
0.056	3.8894	0.137	3.7296	0.217	3.5720	0.297	3.4145	0.378	3.2555	0.458	3.0986	0.539	2.9401
0.057	3.8875	0.138	3.7276	0.218	3.5700	0.298	3.4126	0.379	3.2536	0.459	3.0967	0.540	2.9382
0.058	3.8855	0.139	3.7257	7/32	3.5685	0.299	3.4106	0.380	3.2516	0.460	3.0947	0.541	2.9362
0.059	3.8835	0.140	3.7237	0.219	3.5680	0.300	3.4086	0.381	3.2496	0.461	3.0928	0.542	2.9342
0.060	3.8815	9/64	3.7225	0.220	3.5661	0.301	3.4067	0.382	3.2477	0.462	3.0908	0.543	2.9323
0.061	3.8796	0.141	3.7217	0.221	3.5641	0.302	3.4047	0.383	3.2457	0.463	3.0888	0.544	2.9303
0.062	3.8776	0.142	3.7197	0.222	3.5621	0.303	3.4028	0.384	3.2438	0.464	3.0869	0.545	2.9284
1/16	3.8767	0.143	3.7178	0.223	3.5602	0.304	3.4008	0.385	3.2418	0.465	3.0849	0.546	2.9264
0.063	3.8756	0.144	3.7158	0.224	3.5582	0.305	3.3988	0.386	3.2398	0.466	3.0830	35/64	2.9247
0.064	3.8736	0.145	3.7138	0.225	3.5562	0.306	3.3969	0.387	3.2379	0.467	3.0810	0.547	2.9245
0.065	3.8717	0.146	3.7119	0.226	3.5543	0.307	3.3949	0.388	3.2359	0.468	3.0790	0.548	2.9225
0.066	3.8697	0.147	3.7099	0.227	3.5523	0.308	3.3929	0.389	3.2339	15/32	3.0773	0.549	2.9206
0.067	3.8677	0.148	3.7079	0.228	3.5503	0.309	3.3910	0.390	3.2320	0.469	3.0771	0.550	2.9186
0.068	3.8657	0.149	3.7060	0.229	3.5484	0.310	3.3890	25/64	3.2308	0.470	3.0751	0.551	2.9167
0.069	3.8638	0.150	3.7040	0.230	3.5464	0.311	3.3871	0.391	3.2300	0.471	3.0732	0.552	2.9147
0.070	3.8618	0.151	3.7020	0.231	3.5444	0.312	3.3851	0.392	3.2281	0.472	3.0712	0.553	2.9128
0.071	3.8598	0.152	3.7000	0.232	3.5425	5/16	3.3841	0.393	3.2261	0.473	3.0692	0.554	2.9108
0.072	3.8578	0.153	3.6981	0.233	3.5405	0.313	3.3831	0.394	3.2241	0.474	3.0673	0.555	2.9089
0.073	3.8559	0.154	3.6961	0.234	3.5385	0.314	3.3812	0.395	3.2222	0.475	3.0653	0.556	2.9069
0.074	3.8539	0.155	3.6941	15/64	3.5378	0.315	3.3792	0.396	3.2202	0.476	3.0634	0.557	2.9050
0.075	3.8519	0.156	3.6922	0.235	3.5366	0.316	3.3772	0.397	3.2182	0.477	3.0614	0.558	2.9030
0.076	3.8499	5/32	3.6917	0.236	3.4346	0.317	3.3753	0.398	3.2163	0.478	3.0594	0.559	2.9010
0.077	3.8480	0.157	3.6902	0.237	3.5326	0.318	3.3733	0.399	3.2143	0.479	3.0575	0.560	2.8991
0.078	3.8460	0.158	3.6882	0.238	3.5306	0.319	3.3714	0.400	3.2124	0.480	3.0555	0.561	2.8971
5/64	3.8457	0.159	3.6862	0.239	3.5287	0.320	3.3694	0.401	3.2104	0.481	3.0536	0.562	2.8952
0.079	3.8440	0.160	3.6843	0.240	3.5267	0.321	3.3674	0.402	3.2084	0.482	3.0516	9/16	2.8942
0.080	3.8421	0.161	3.6823	0.241	3.5247	0.322	3.3655	0.403	3.2064	0.483	3.0496	0.563	2.8932

Machinery

DIMENSIONS OF CIRCULAR FORMING TOOLS FOR NO. 6 B. & S. AUTOMATIC SCREW MACHINE—Continued

Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool
0.564	2.8913	0.645	2.7334	0.725	2.5779	0.806	2.4209	0.887	2.2648	0.967	2.1115	1.047	1.9592
0.565	2.8893	0.646	2.7314	0.726	2.5759	0.807	2.4190	0.888	2.2629	0.968	2.1096	1.048	1.9573
0.566	2.8874	0.647	2.7295	0.727	2.5740	0.808	2.4171	0.889	2.2610	31/32	2.1082	1.049	1.9554
0.567	2.8854	0.648	2.7276	0.728	2.5721	0.809	2.4151	0.890	2.2590	0.969	2.1077	1.050	1.9535
0.568	2.8835	0.649	2.7256	0.729	2.5701	0.810	2.4132	57/64	2.2578	0.970	2.1058	1.051	1.9516
0.569	2.8815	0.650	2.7237	0.730	2.5682	0.811	2.4113	0.891	2.2571	0.971	2.1039	1.052	1.9497
0.570	2.8796	0.651	2.7217	0.731	2.5662	0.812	2.4093	0.892	2.2552	0.972	2.1020	1.053	1.9479
0.571	2.8776	0.652	2.7198	0.732	2.5643	13/16	2.4083	0.893	2.2533	0.973	2.1001	1.054	1.9460
0.572	2.8757	0.653	2.7178	0.733	2.5624	0.813	2.4074	0.894	2.2514	0.974	2.0981	1.055	1.9441
0.573	2.8737	0.654	2.7159	0.734	2.5604	0.814	2.4055	0.895	2.2494	0.975	2.0962	1.056	1.9422
0.574	2.8717	0.655	2.7139	47/64	2.5597	0.815	2.4035	0.896	2.2475	0.976	2.0944	1.057	1.9403
0.575	2.8698	0.656	2.7120	0.735	2.5585	0.816	2.4016	0.897	2.2456	0.977	2.0925	1.058	1.9384
0.576	2.8678	21/32	2.7115	0.736	2.5565	0.817	2.3997	0.898	2.2437	0.978	2.0906	1.059	1.9365
0.577	2.8659	0.657	2.7100	0.737	2.5546	0.818	2.3977	0.899	2.2418	0.979	2.0886	1.060	1.9346
0.578	2.8639	0.658	2.7081	0.738	2.5527	0.819	2.3958	0.900	2.2398	0.980	2.0867	1.061	1.9327
37/64	2.8636	0.659	2.7061	0.739	2.5507	0.820	2.3939	0.901	2.2379	0.981	2.0848	1.062	1.9308
0.579	2.8620	0.660	2.7042	0.740	2.5488	0.821	2.3920	0.902	2.2360	0.982	2.0829	1 1/16	1.9298
0.580	2.8600	0.661	2.7022	0.741	2.5469	0.822	2.3900	0.903	2.2341	0.983	2.0810	1.063	1.9289
0.581	2.8581	0.662	2.7003	0.742	2.5449	0.823	2.3881	0.904	2.2321	0.984	2.0791	1.064	1.9270
0.582	2.8561	0.663	2.6983	0.743	2.5430	0.824	2.3862	0.905	2.2302	63/64	2.0784	1.065	1.9252
0.583	2.8542	0.664	2.6964	0.744	2.5410	0.825	2.3842	0.906	2.2283	0.985	2.0772	1.066	1.9233
0.584	2.8522	0.665	2.6945	0.745	2.5391	0.826	2.3823	29/32	2.2278	0.986	2.0753	1.067	1.9214
0.585	2.8503	0.666	2.6925	0.746	2.5372	0.827	2.3804	0.907	2.2264	0.987	2.0734	1.068	1.9195
0.586	2.8483	0.667	2.6906	0.747	2.5352	0.828	2.3785	0.908	2.2245	0.988	2.0715	1.069	1.9176
0.587	2.8464	0.668	2.6886	0.748	2.5333	53/64	2.3782	0.909	2.2226	0.989	2.0695	1.070	1.9157
0.588	2.8444	0.669	2.6867	0.749	2.5313	0.829	2.3765	0.910	2.2206	0.990	2.0676	1.071	1.9138
0.589	2.8425	0.670	2.6847	0.750	2.5294	0.830	2.3746	0.911	2.2187	0.991	2.0657	1.072	1.9119
0.590	2.8405	0.671	2.6828	0.751	2.5275	0.831	2.3727	0.912	2.2168	0.992	2.0638	1.073	1.9100
0.591	2.8385	43/64	2.6811	0.752	2.5255	0.832	2.3708	0.913	2.2149	0.993	2.0619	1.074	1.9081
0.592	2.8366	0.672	2.6808	0.753	2.5236	0.833	2.3688	0.914	2.2130	0.994	2.0600	1.075	1.9062
0.593	2.8346	0.673	2.6789	0.754	2.5217	0.834	2.3669	0.915	2.2111	0.995	2.0581	1.076	1.9044
19/32	2.8332	0.674	2.6769	0.755	2.5197	0.835	2.3650	0.916	2.2091	0.996	2.0562	1.077	1.9025
0.594	2.8327	0.675	2.6750	0.756	2.5178	0.836	2.3630	0.917	2.2072	0.997	2.0543	1.078	1.9007
0.595	2.8307	0.676	2.6730	0.757	2.5158	0.837	2.3611	0.918	2.2053	0.998	2.0524	1 5/64	1.9005
0.596	2.8288	0.677	2.6711	0 758	2.5139	0.838	2.3592	0.919	2.2034	0.999	2.0504	1.079	1.8988
0.597	2.8268	0.678	2.6691	0.759	2.5120	0.839	2.3572	0.920	2.2015	1.000	2.0485	1.080	1.8969
0.598	2.8249	0.679	2.6672	0.760	2.5100	0.840	2.3553	0.921	2.1995	1.001	2.0466	1.081	1.8950
0.599	2.8229	0.680	2.6653	0.761	2.5081	0.841	2.3534	59/64	2.1978	1.002	2.0447	1.082	1.8931
0.600	2.8210	0.681	2.6633	0.762	2.5062	0.842	2.3515	0.922	2.1976	1.003	2.0428	1.083	1.8912
0.601	2.8191	0.682	2.6614	0.763	2.5042	0.843	2.3495	0.923	2.1957	1.004	2.0409	1.084	1.8893
0.602	2.8171	0.683	2.6594	0.764	2.5023	27/32	2.3480	0.924	2.1938	1.005	2.0390	1.085	1.8874
0.603	2.8152	0.684	2.6575	0.765	2.5003	0.844	2.3476	0.925	2.1919	1.006	2.0371	1.086	1.8855
0.604	2.8132	0.685	2.6555	49/64	2.4991	0.845	2.3457	0.926	2.1900	1.007	2.0352	1.087	1.8836
0.605	2.8113	0.686	2.6536	0.766	2.4984	0.846	2.3437	0.927	2.1880	1.008	2.0333	1.088	1.8818
0.606	2.8093	0.687	2.6516	0.767	2.4965	0.847	2.3418	0.928	2.1861	1.009	2.0314	1.089	1.8799
0.607	2.8074	11/16	2.6506	0.768	2.4945	0.848	2.3399	0.929	2.1842	1.010	2.0295	1.090	1.8780
0.608	2.8054	0.688	2.6497	0.769	2.4926	0.849	2.3379	0.930	2.1823	1.011	2.0276	1.091	1.8761
0.609	2.8035	0.689	2.6477	0.770	2.4907	0.850	2.3360	0.931	2.1804	1.012	2.0257	1.092	1.8742
39/64	2.8028	0.690	2.6458	0.771	2.4887	0.851	2.3340	0.932	2.1785	1.013	2.0238	1.093	1.8723
0.610	2.8015	0.691	2.6438	0.772	2.4868	0.852	2.3321	0.933	2.1765	1.014	2.0219	1 3/32	1.8709
0.611	2.7996	0.692	2.6419	0.773	2.4848	0.853	2.3301	0.934	2.1746	1.015	2.0200	1.094	1.8704
0.612	2.7976	0.693	2.6399	0.774	2.4829	0.854	2.3282	0.935	2.1727	1 1/64	2.0188	1.095	1.8685
0.613	2.7957	0.694	2.6380	0.775	2.4810	0.855	2.3263	0.936	2.1708	1.016	2.0181	1.096	1.8666
0.614	2.7938	0.695	2.6360	0.776	2.4790	0.856	2.3244	0.937	2.1689	1.017	2.0162	1.097	1.8647
0.615	2.7918	0.696	2.6341	0.777	2.4771	0.857	2.3225	15/16	2.1679	1.018	2.0143	1.098	1.8629
0.616	2.7899	0.697	2.6322	0.778	2.4751	0.858	2.3205	0.938	2.1670	1.019	2.0124	1.099	1.8610
0.617	2.7879	0.698	2.6302	0.779	2.4732	0.859	2.3186	0.939	2.1650	1.020	2.0105	1.100	1.8591
0.618	2.7860	0.699	2.6283	0.780	2.4713	55/64	2.3179	0.940	2.1631	1.021	2.0086	1.101	1.8572
0.619	2.7840	0.700	2.6263	0.781	2.4693	0.860	2.3167	0.941	2.1612	1.022	2.0067	1.102	1.8553
0.620	2.7821	0.701	2.6244	25/32	2.4688	0.861	2.3148	0.942	2.1593	1.023	2.0048	1.103	1.8534
0.621	2.7801	0.702	2.6224	0.782	2.4674	0.862	2.3129	0.943	2.1574	1.024	2.0029	1.104	1.8515
0.622	2.7782	0.703	2.6205	0.783	2.4655	0.863	2.3109	0.944	2.1555	1.025	2.0010	1.105	1.8497
0.623	2.7762	45/64	2.6202	0.784	2.4635	0.864	2.3090	0.945	2.1536	1.026	1.9991	1.106	1.8478
0.624	2.7743	0.704	2.6186	0.785	2.4616	0.865	2.3071	0.946	2.1516	1.027	1.9972	1.107	1.8459
0.625	2.7723	0.705	2.6166	0.786	2.4596	0.866	2.3052	0.947	2.1497	1.028	1.9953	1.108	1.8440
0.626	2.7704	0.706	2.6147	0.787	2.4577	0.867	2.3033	0.948	2.1478	1.029	1.9934	1.109	1.8421
0.627	2.7684	0.707	2.6127	0.788	2.4558	0.868	2.3013	0.949	2.1459	1.030	1.9915	1 7/64	1.8414
0.628	2.7665	0.708	2.6108	0.789	2.4538	0.869	2.2994	0.950	2.1440	1.031	1.9896	1.110	1.8403
0.629	2.7645	0.709	2.6089	0.790	2.4519	0.870	2.2975	0.951	2.1421	1 1/32	1.9891	1.111	1.8384
0.630	2.7626	0.710	2.6069	0.791	2.4500	0.871	2.2956	0.952	2.1402	1.032	1.9877	1.112	1.8365
0.631	2.7607	0.711	2.6050	0.792	2.4480	0.872	2.2937	0.953	2.1383	1.033	1.9858	1.113	1.8346
0.632	2.7587	0.712	2.6031	0.793	2.4461	0.873	2.2917	61/64	2.1381	1.034	1.9839	1.114	1.8327
0.633	2.7568	0.713	2.6011	0.794	2.4441	0.874	2.2898	0.954	2.1363	1.035	1.9820	1.115	1.8309
0.634	2.7548	0.714	2.5992	0.795	2.4422	0.875	2.2879	0.955	2.1344	1.036	1.9801	1.116	1.8290
0.635	2.7529	0.715	2.5972	0.796	2.4403	0.876	2.2859	0.956	2.1325	1.037	1.9782	1.117	1.8271
0.636	2.7509	0.716	2.5953	51/64	2.4386	0.877	2.2840	0.957	2.1306	1.038	1.9763	1.118	1.8252
0.637	2.7490	0.717	2.5934	0.797	2.4383	0.878	2.2821	0.958	2.1287	1.039	1.9744	1.119	1.8233
0.638	2.7470	0.718	2.5914	0.798	2.4364	0.879	2.2802	0.959	2.1268	1.040	1.9725	1.120	1.8215
0.639	2.7451	23/32	2.5899	0.799	2.4344	0.880	2.2782	0.960	2.1249	1.041	1.9706	1.121	1.8196
0.640	2.7431	0.719	2.5895	0.800	2.4325	0.881	2.2763	0.961	2.1230	1.042	1.9687	1.122	1.8177
41/64	2.7419	0.720	2.5876	0.801	2.4306	0.882	2.2744	0.962	2.1211	1.043	1.9668	1.123	1.8158
0.641	2.7412	0.721	2.5856	0.802	2.4286	0.883	2.2725	0.963	2.1192	1.044	1.9649	1.124	1.8139
0.642	2.7392	0.722	2.5837	0.803	2.4267	0.884	2.2706	0.964	2.1172	1.045	1.9630	1.125	1.8121
0.643	2.7373	0.723	2.5817	0.804	2.4248	0.885	2.2686	0.965	2.1153	1.046	1.9611	1.126	1.8102
0.644	2.7353	0.724	2.5798	0.805	2.4229	0.886	2.2667	0.966	2.1134	1 3/64	1.9594	1.127	1.8083

Machinery

DIMENSIONS OF CIRCULAR FORMING TOOLS FOR NO. 6 B. & S. AUTOMATIC SCREW MACHINE—Continued

Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool	Length c on Tool	Required Diameter of Tool
1.128	1.8064	1.147	1.7709	1.166	1.7354	1.185	1.7000
1.129	1.8046	1.148	1.7690	1.167	1.7335	1.186	1.6981
1.130	1.8027	1.149	1.7672	1.168	1.7316	1.187	1.6963
1.131	1.8008	1.150	1.7653	1.169	1.7298	$1\frac{3}{16}$	1.6954
1.132	1.7989	1.151	1.7634	1.170	1.7279	1.188	1.6944
1.133	1.7971	1.152	1.7615	1.171	1.7260	1.189	1.6925
1.134	1.7952	1.153	1.7597	$1\frac{11}{64}$	1.7244	1.190	1.6907
1.135	1.7933	1.154	1.7578	1.172	1.7241	1.191	1.6888
1.136	1.7915	1.155	1.7559	1.173	1.7223	1.192	1.6870
1.137	1.7896	1.156	1.7541	1.174	1.7204	1.193	1.6851
1.138	1.7877	$1\frac{5}{32}$	1.7536	1.175	1.7185	1.194	1.6832
1.139	1.7859	1.157	1.7522	1.176	1.7167	1.195	1.6814
1.140	1.7840	1.158	1.7503	1.177	1.7149	1.196	1.6795
$1\frac{9}{64}$	1.7828	1.159	1.7485	1.178	1.7130	1.197	1.6777
1.141	1.7821	1.160	1.7466	1.179	1.7111	1.198	1.6758
1.142	1.7802	1.161	1.7447	1.180	1.7093	1.199	1.6739
1.143	1.7784	1.162	1.7428	1.181	1.7074	1.200	1.6721
1.144	1.7765	1.163	1.7410	1.182	1.7056	.....	......
1.145	1.7746	1.164	1.7391	1.183	1.7037	.....	......
1.146	1.7728	1.165	1.7372	1.184	1.7018	.....	......

Machinery

* * *

MACHINING A BALL AND SOCKET JOINT

BY CHESTER S. RICKER*

On Paige-Detroit motor cars there is a ball and socket joint which has to be machined very carefully, as it has heavy duty to perform. This joint is located at the forward end of the torque tube which is attached to the rear axle. It serves a double purpose, *i. e.*, to transmit the driving action and to resist the torque or tendency of the rear axle to rotate about the axis of the wheels. At the same time, it must be free to move about its center as the rear axle rises and falls, due to spring action. Furthermore, the center of the ball and socket must be coincident with a universal joint which the ball encloses. The methods of making these two pieces on a Bullard vertical turret lathe are shown in the accompanying illustrations. About fifty per hour is the rate of production on both pieces, although output on the socket usually runs slightly less because of the additional work required in facing off the flange in addition to machining the socket.

* Address: 1201 State Life Bldg., Indianapolis, Ind.

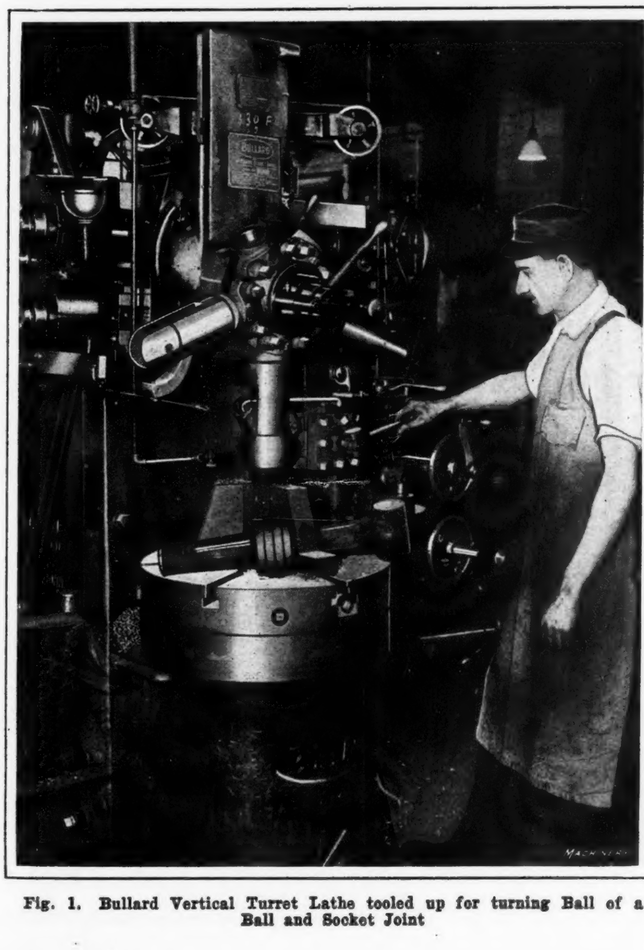


Fig. 1. Bullard Vertical Turret Lathe tooled up for turning Ball of a Ball and Socket Joint

Both tools are designed on the same principle. Heavy cylindrical bars are mounted in the turret, the end of these bars being slotted to carry the tools. The tool for machining the socket, Fig. 2, is a circular disk of slightly smaller diameter than the socket and of suitable thickness to just fit in the slot in the bar. A weight and cord are used to keep the tool out of engagement with the work. The cord is secured in place by a hook, so that it only requires a second to release it when the turret has to be rotated to the next position. The same is true of the feeding device which is hooked to the tool and to the transverse tool-holder. When the tool has been lowered into the work until the center is coincident with the center of the socket, the cross-feed is started, the work having already been started rotating.

The method of attaching the weight and the feed-bar is most clearly shown in the illustration of the ball, Fig. 1, which also shows a piece of work unfinished, one that is semi-finished, and one in the chuck that is completely finished. The "semi-finishing" tool is shown at the left side of the turret in the first position above the tool which is at work. It shows very clearly the design of the tool-holder and the rotary piece carrying the cutter. Both pieces are made from malleable iron.

Fig. 2. Bullard Vertical Turret Lathe tooled up for turning Socket of a Ball and Socket Joint

* * *

POLISHING STRAP SPEEDS

Several modifications of belt type polishing machines are in use, but they all consist essentially of two flanged pulleys, carrying a canvas belt coated with glue and abrasives on the outer side. They are often called strapping or strap buffing machines. The straps or polishing belts run at speeds of from 2000 to 2500 feet per minute generally, and are effective for finishing irregular surfaces, especially on brass work. They have found a considerable field of usefulness in polishing surfaces that are inaccessible with the polishing wheel. Experience has shown that the finer woven belts hold the abrasive materials better than those that are coarser woven.—*Grits and Grinds.*

ELECTRIC SPOT-WELDING PRACTICE—2*

APPLICATION OF ELECTRIC SPOT-WELDING MACHINES TO VARIOUS WELDING PROCESSES

BY DOUGLAS T. HAMILTON†

WHILE the operation of an electric spot-welding machine is comparatively simple, there are a number of points in connection with it, as well as the preparation of the material, that should receive careful attention. As has been previously explained in the article which appeared in the August number of MACHINERY, it is necessary to vary the pressure, current and time, depending on the thickness of the stock and the character of the material being spot-welded. Another point is the cleaning of the material and the preparation of it when other than the regular spot-welding operations are being performed. These points, together with a description of some of the more practical applications of a spot-welding machine to various welding processes, will be covered in the following.

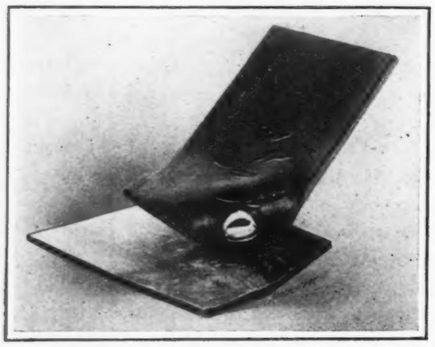


Fig. 1. Results of an Endeavor to separate Two Pieces of Sheet Steel that have been spot-welded—Note how Metal around Welded Spot is tearing away and Welded Spot remains Intact, forming one Sheet with the Lower Piece

Preparation of Work for Spot-welding

In welding sheet metal, the best results can be obtained when the stock is clean and free from scale, rust or dirt. The cleaner and better the stock the easier it is to weld, and the less current it takes to accomplish the work. It will also be found that when the metal is clean and free from scale the electrodes will wear much longer than when the stock is dirty. Electrodes should be kept clean and firmly held in their holders. If dirt is allowed to gather around the sockets that hold the electrodes, good contact cannot be made. Dirt and grease as well as scale are non-conductors of electric current, and with the low voltage employed in electric spot-welding machines, it takes very little dirt, grease or scale to make poor contact and obtain poor results. In fact, the entire machine should be kept clean, and if there is undue heating at any point, it is a clear indication that there is poor contact, and this should be remedied without delay. Loose joints in the machine mean that there is poor contact and resultant heating with a decrease in power. Care should be taken to see that the bolts fastening the copper leads or secondary circuit to the transformer and the copper blocks holding the electrodes are tightened.

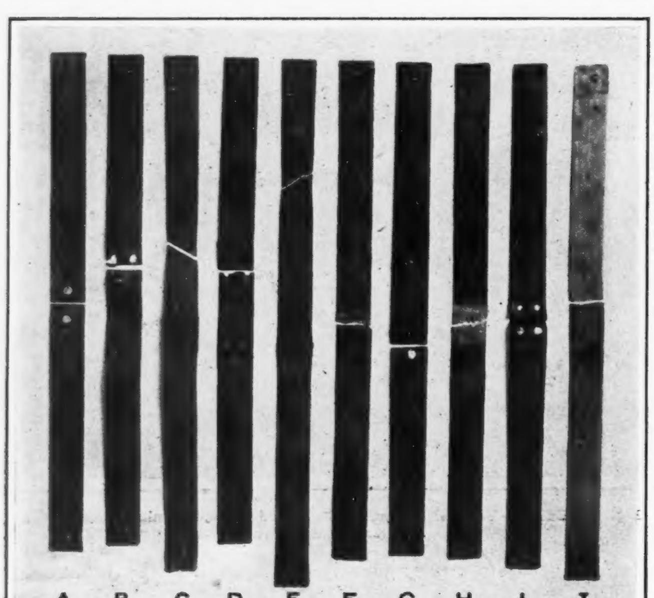


Fig. 2. Results of Tests made to show Comparative Strength of Spot-welded and Riveted Joints

Other electric welding processes which can be accomplished on a spot-welding machine require in most cases a previous mechanical preparation of the stock. Some of these processes are known as point-welding, bridge-welding, T-welding, etc. The methods used in preparing the stock for accomplishing these various processes will be described in the following.

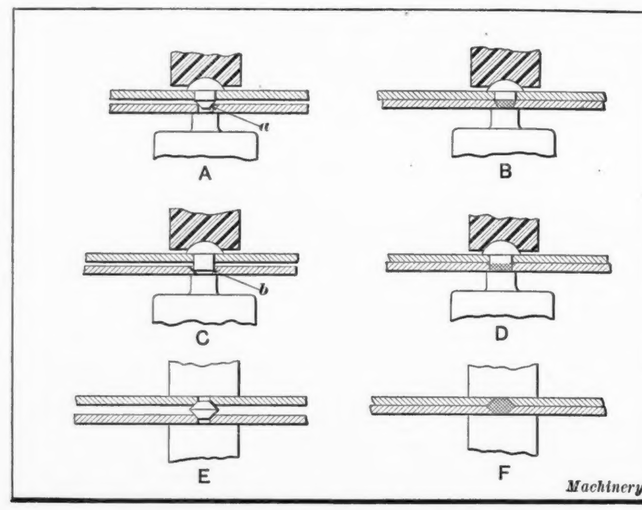


Fig. 3. Diagram illustrating Various Processes of accomplishing Electric Riveting on a Spot-welding Machine

TABLE OF TIME AND POWER REQUIRED AND COST OF SPOT-WELDING SHEET STEEL AND IRON

No. of Sheet Steel Gage U. S. Standard	Thickness in Fractions of an Inch	Decimal Equivalent in Inches	Approximate K. W. Required	H. P. at Dynamo	Time in Seconds to Make a Weld	Cost of 1000 Welds at 1 cent per K. W. Hour
28	1/64	0.0156	4.0	5.7	0.25	$0.00278
26	3/160	0.0187	5.5	7.9	0.30	0.00458
24	1/40	0.0250	7.0	10.0	0.40	0.00774
22	1/32	0.0312	8.0	11.4	0.50	0.01110
20	3/80	0.0375	9.0	12.9	0.55	0.01375
18	1/20	0.0500	10.0	14.3	0.70	0.01945
16	1/16	0.0625	12.0	17.1	0.85	0.02840
14	5/64	0.0781	13.5	19.3	1.00	0.03750
12	7/64	0.1093	16.5	23.6	1.30	0.05950
10	9/64	0.1406	19.0	27.2	1.70	0.08950
9	5/32	0.1562	20.0	28.6	1.80	0.10000
8	11/64	0.1718	21.5	30.7	2.00	0.11950
7	3/16	0.1875	22.5	32.1	2.10	0.13100
6	13/64	0.2031	23.5	33.6	2.20	0.14350
5	7/32	0.2187	24.5	35.0	2.35	0.16000
4	15/64	0.2343	25.5	36.4	2.45	0.17300
3	1/4	0.2500	26.5	37.8	2.60	0.19100
1	9/32	0.2812	28.5	40.7	2.80	0.22200
0	5/16	0.3125	29.5	42.0	2.95	0.24100
000	3/8	0.3750	33.5	47.8	3.50	0.30800
00000	7/16	0.4375	36.5	52.0	4.00	0.40500
0000000	1/2	0.5000	39.5	56.4	4.45	0.48800
....	9/16	0.5625	42.2	60.3	4.90	0.57400
....	5/8	0.6250	45.0	64.3	5.40	0.67600
....	11/16	0.6875	47.7	68.2	5.84	0.77300
....	3/4	0.7500	50.7	72.5	6.30	0.88800
....	13/16	0.8125	53.5	76.5	6.80	1.01000
....	7/8	0.8750	56.3	80.5	7.25	1.13500
....	1	1.0000	62.0	88.6	8.20	1.41300

* For information on electric welding previously published in MACHINERY, see "Electric Spot Welding," August, 1916, and other articles there referred to.
† Associate Editor of MACHINERY.

Power and Time Required for Electric Spot-welding

The power required for operating an electric welding machine depends on the size of the machine, character and thickness of the material being welded, and the time taken to make the weld. In operating all electric welding machines of the resistance type, alternating current should be used of either 220 or 440 volts, 60 cycles. Where the frequency varies from 60, for instance 25, a special transformer adapted to this lower frequency is necessary. Voltages higher than 450—up to 550 or 600—are more dangerous to handle, and it is advisable to use a remote control switch mounted on the wall at some distance from the machine. This prevents any possibility of the operator coming in contact with this dangerous current when operating the welding machine. Where two or three phase current is available, only one phase of the multi-phase system should be used. Inside the welding machine and

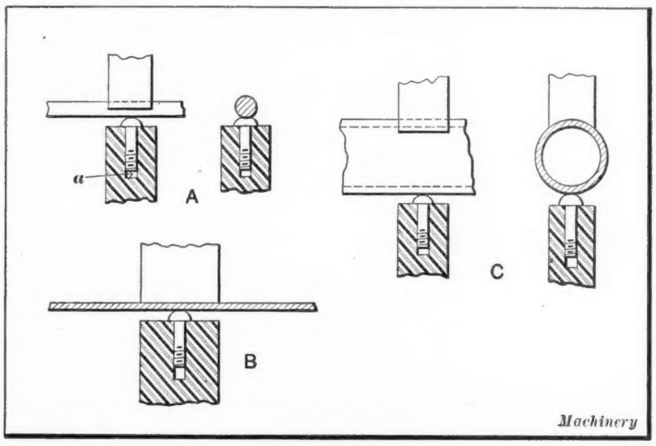


Fig. 4. Diagram illustrating Processes of welding Screws to Sheet Tubing, etc.

forming a part of it is a transformer which transforms the voltage from 220 to 440 down to three to five volts, which is the pressure used in all "stock" machines for making the average weld in sheet metal. This voltage is so low that it cannot be felt by the bare hands, and explains why it is absolutely safe for the operator.

The accompanying table gives the approximate amount of power required for welding a given thickness of sheet steel in a given time. This can be varied at will, as the time can be shortened by increasing the power, or the amount of power can be decreased by taking a longer time to do the work. In both cases the cost of the current will be the same. In this table the cost for current is based on one thousand welds at a cost of one cent per kilowatt-hour. To obtain the approximate

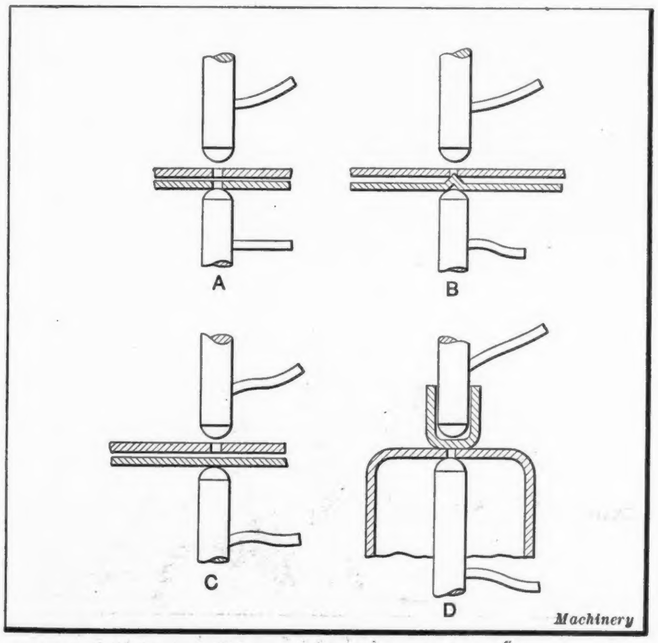


Fig. 5. Diagram illustrating Processes used in spot-welding Large Articles

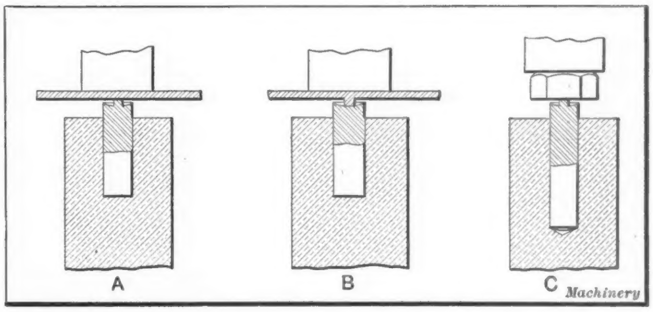


Fig. 6. Diagram illustrating Process of uniting Sheets to Studs and Bolt Bodies to Heads

cost for welding various thicknesses of stock, multiply the price given in the last column by the rate per kilowatt charged by the local electric light company, which will give the cost per one thousand welds. For example, suppose the material being welded is 1/16-inch sheet steel. The power required would be 12 kilowatts, time 0.85 second, and the cost per one thousand welds, figuring on a basis of eight cents per kilowatt-hour, would be 22.7 cents.

Strength of Spot-welded Joints

One of the chief advantages of electric spot-welding is that it takes the place of riveting on many classes of work, and not only does the work more rapidly, but also more effectively.

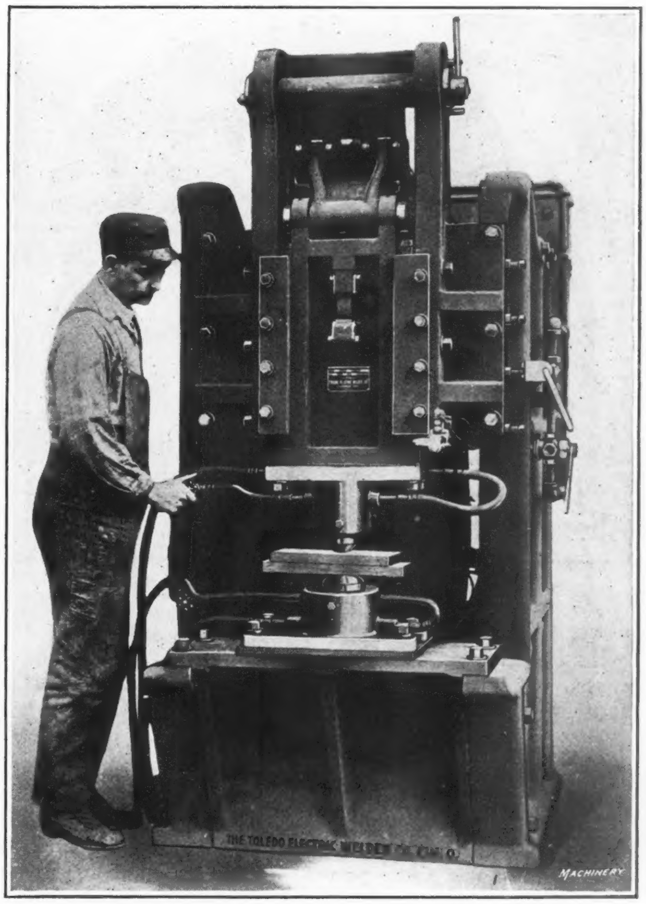


Fig. 7. Special Toledo Electric Spot-welder having a Capacity to weld Two Plates each $1\frac{1}{4}$ inch Thick and applying Hydraulic Pressure for operating the Upper Electrode

For instance, an electric spot-welded joint is stronger than a riveted joint. The examples shown in Fig. 2 give some idea as to the efficiency of a welded joint as compared with one that is riveted. The data pertaining to these tests are as follows: The strip *A* was spot-welded in one place, and broke at the weld when a tensile pull of 1625 pounds was exerted on it. The strip *B* was spot-welded in two places and also riveted in two places. It broke at the riveted joint when a pull of 1555 pounds was reached. The strip *C* was spot-welded in three places and broke outside the weld when a pull of 2715 pounds was exerted. It should be noticed in this case that

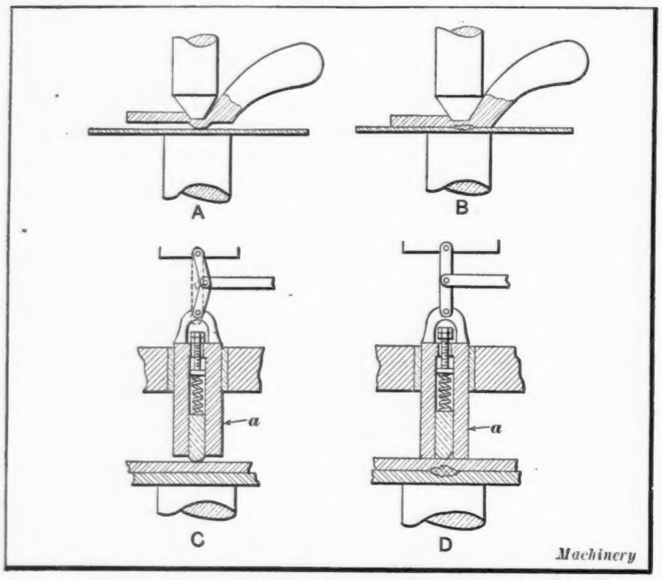


Fig. 8. Diagram illustrating Principles of welding Thick to Thin Metal and welding Thick Sheets of Metal

Electric Riveting on a Spot-welding Machine

There are certain classes of work where a rivet is desired, and previous to the adoption of the electric welding machine, of course, the rivet was upset by a riveting machine. An electric welding machine can be used to good advantage on this work, however, because the rivet, instead of being closed over in a cold state, is heated by the electrodes of the machine, and hence makes a much better joint that if it were riveted over cold. Fig. 3 shows several different methods of performing electric riveting operations. At *A* is shown one method. Here it will be noticed that two plates are to be joined by a rivet. The top plate is provided with a larger hole than the bottom plate, and the rivet is pointed. Using a combination of this sort makes a very strong joint because the heat is localized at the point *a* which, when the plates are pressed together, acts as a junction point. The result of a weld of this character is shown at *B*.

Still another application of electric riveting is shown at *C*. In this case the lower plate is provided with a taper hole and the rivet with square corners. Again the heat is localized in the lower plate at the point *b*, and a satisfactory weld can be accomplished, as shown diagrammatically at *D*.

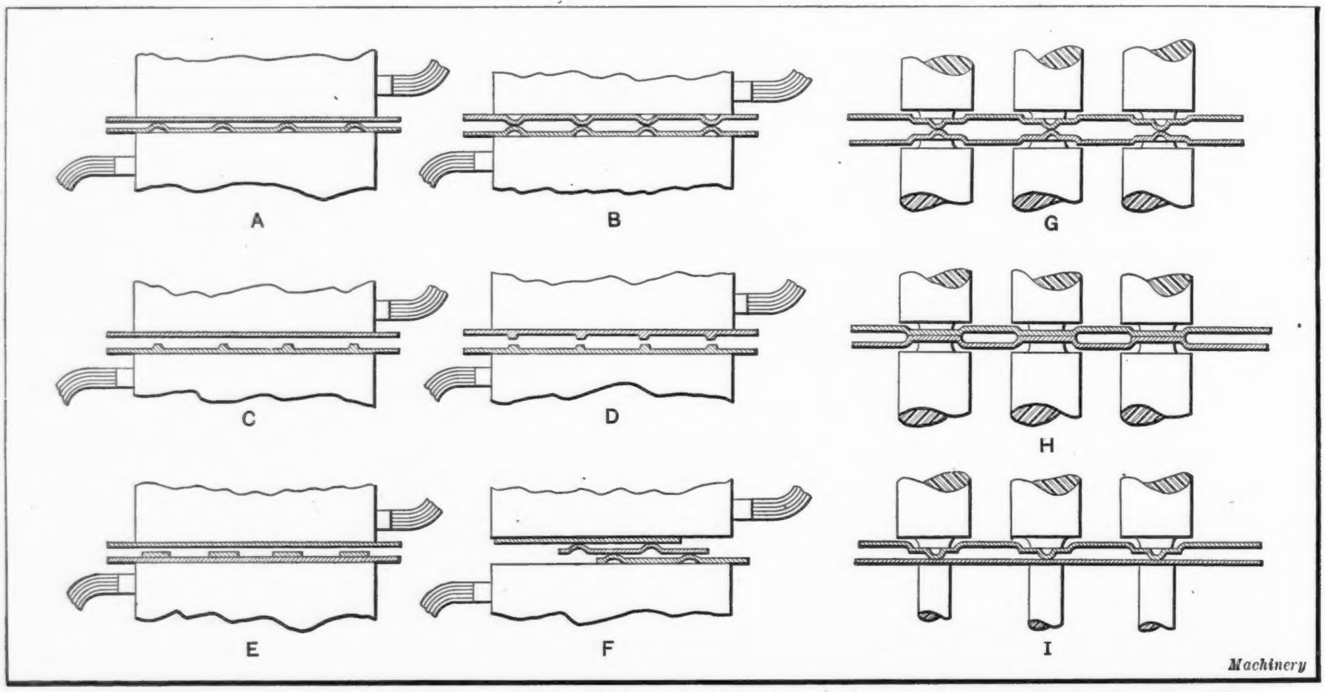


Fig. 9. Diagram illustrating Various Processes of accomplishing Multiple Point- or Projection-welding and Multiple Electrode welding

the metal was elongated considerably at the point where the break took place. The strip *D* was spot-welded in three places and also had three rivets. It broke at the riveted joint when a pull of 2055 pounds was exerted. The strip *E* was lap-welded and broke outside the weld when a tensile pull of 2720 pounds was reached on the indicator. Strip *F* was butt-welded and broke at the weld when a tensile pull of 2555 pounds was reached. Strip *G* was spot-welded and riveted in one place. It broke at the rivet with a pull of 990 pounds. The strip *H* was lap-welded and broke at the weld when a tensile pull of 2425 pounds was reached. Strip *I* was spot-welded in two places and broke at the weld when a pull of 2275 pounds was reached. Strip *J* is a plain piece of hoop iron, which was not welded, and broke when a pull of 2690 pounds was reached. By looking over these tests it will be noticed that in all cases the electrically welded joints were stronger than the riveted ones.

Another example which illustrates the effectiveness of a spot-welded joint is shown in Fig. 1. In this case two pieces of sheet steel of the same thickness have been spot-welded at one point. In endeavoring to separate these two pieces it will be noticed that the welded joint still held and that the metal around the weld gave way. This is a different test from those previously illustrated in that no tensile pull on the joint has been made.

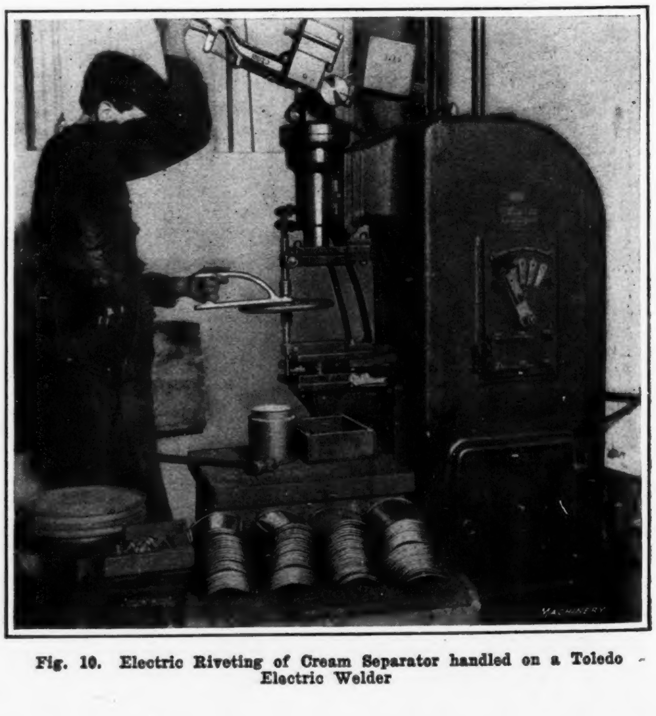


Fig. 10. Electric Riveting of Cream Separator handled on a Toledo Electric Welder

When it is desirable to have both surfaces of the plates smooth, the method shown at *E* can be adopted. Here a double cone rivet is interposed between the two plates, which as illustrated, are provided with holes equal in diameter to about the smallest diameter of the cone-shaped rivet. When the current is turned on and pressure applied, the rivet is "fused" and forms a perfect junction between the two plates, as illustrated at *F*.

A practical application of electric welding is shown in Fig. 10. Here the machine is used for welding a bracket to a cream separator pail shell. The operator first places the rivet in the bracket and shell, then places them on the electrode of the machine, as shown, turns on the current, and applies pressure. As soon as the rivet reaches a bright red heat it upsets considerably, but owing to the large size rivets used the electrodes are not depended upon to completely upset the rivet, as this would cause excessive wear of the electrodes. The work is, therefore, removed from the machine as soon as the rivet is thoroughly heated and smashed down with a hammer on the block shown. One operator by this method can turn out 900 riveted shells in nine hours.

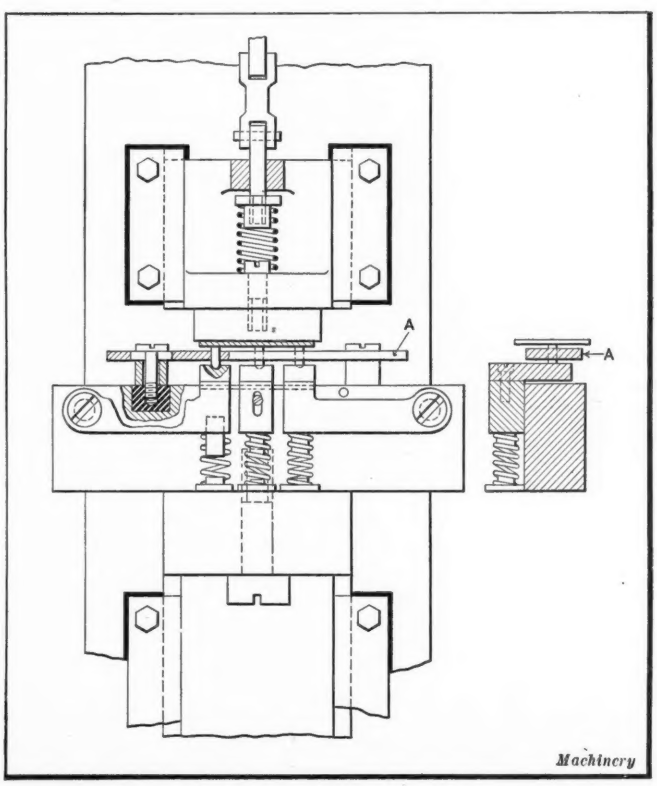


Fig. 11. Diagram illustrating Principle of Machine employing Three Electrodes for welding Pins to Sheet Steel—Compensation is made for Variation in Length of Pins

Butt-welding on an Electric Spot-welding Machine

As has been previously stated, the electric spot-welding ma-

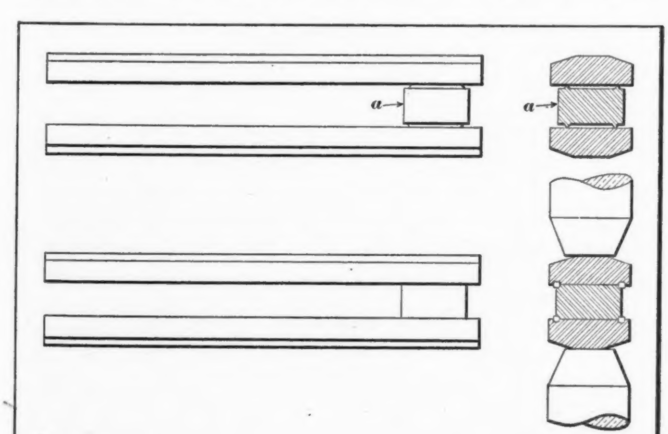


Fig. 12. Diagram illustrating Principle applied in the spot-welding of Telephone Transmitter Magnet Bars without drawing the Temper

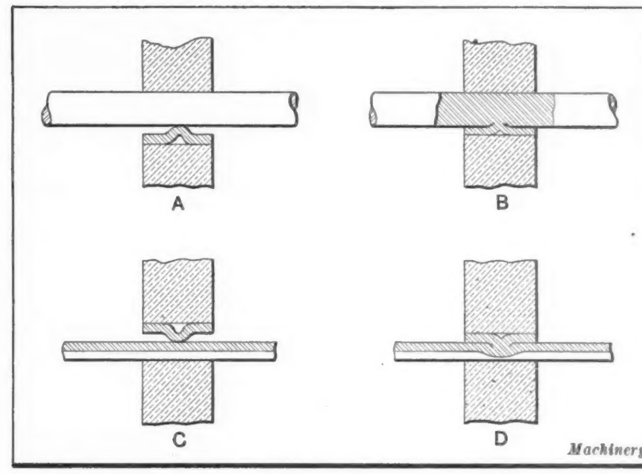


Fig. 13. Diagram illustrating Process known as "Ridge-welding"

chine can be used for performing welding operations by a variety of processes. One process which resembles butt-

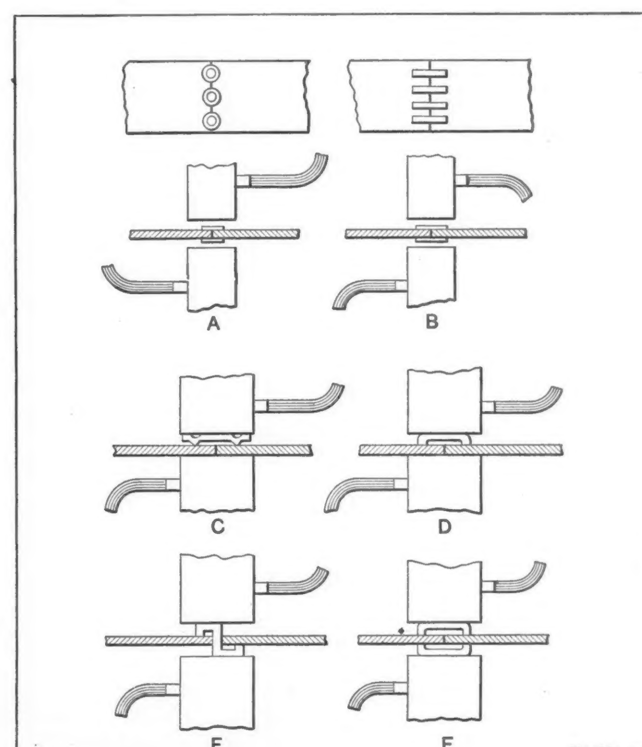


Fig. 14. Diagram illustrating Principle employed in accomplishing Process known as "Bridge- or Tie-welding," permitting the joining of Narrow Strips without decreasing Length

welding is shown in Fig. 6. At *A* is shown one method of welding a rod to a sheet. In order to localize the current at a point, the rod is prepared with a teat and a cup-shaped top. The teat first comes in contact with the sheet, and as this is broken down by the pressure of the electrode the ring around the rod then comes in contact, making a second connection, and greatly intensifies the resistance to the flow of the current so that the rod can be welded to the sheet without leaving practically any burr. Another modification of this principle is shown at *B*. In this case the sheet instead of the rod is prepared with a teat, and the rod is made with a concave or cupped end. *C* in this same illustration shows still another method which is applied in this case to a hexagon bolt. This application is almost identical with that shown at *A*, except that a bolt head instead of a thin sheet of metal is being welded. This method of making cap-screws economizes in material and at the same time makes a strong cap-screw.

Fig. 4 shows some additional examples of butt-welding accomplished on a spot-welding machine. At *A* is shown a method of welding a screw to a rod. This can be done very

satisfactorily on the spot-welding machine, provided that a clearance is left at the bottom of the screw or at the point *a* so that the electrode contacts only with the rim or head of the screw. This enables the welding to be done rapidly and decreases the amount of current used. A somewhat similar method of welding is shown at *B*. Here a screw is being welded to a sheet. The process in this case is identical with that shown at *A*, with the exception of a slight change in the shape of the upper electrode.

Another modification of this principle is shown at *C*. In this case the screw is being welded to a tube. There are two points in connection with this method that should be closely observed. In the first place, the screw must be located in relation to the tube so that the axis of the screw is in line with the axis of the screw and the upper electrode. If this is not the case, there will be a slight deflective movement and a satisfactory weld will not be accomplished. Another thing is that the welding must be done very rapidly to prevent "scattering" the electric current. In fact, the quicker the welding is done the better the results obtained.

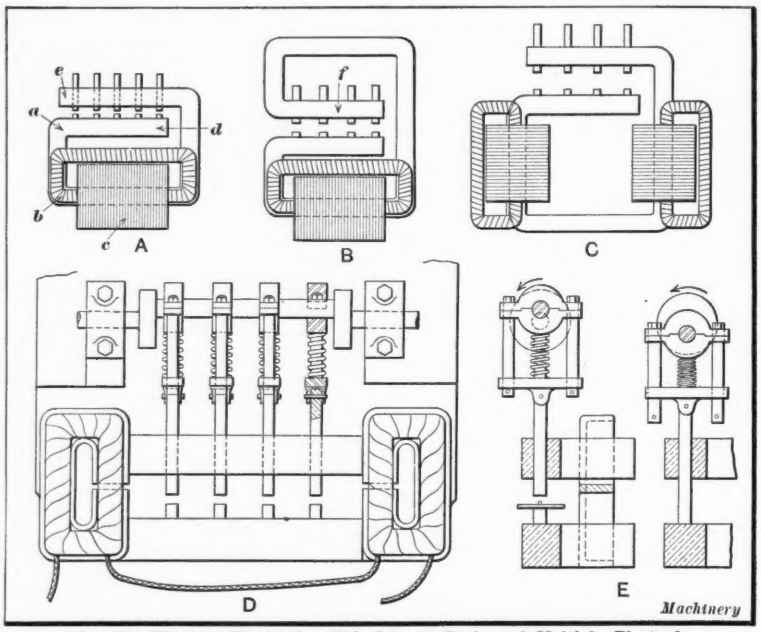


Fig. 16. Diagram illustrating Principle of Design of Multiple Electrode Welding Machines

Spot-welding Large Articles

When it is desired to electrically weld large articles at a very small point, several different processes, as shown in Fig. 5, can be adopted. One process which is shown at *A* consists in drilling two small holes through the pieces of the metal to be welded. When the electric current is applied and the electrodes are brought in contact with the two sheets, the current is localized around the hole and does not spread out into the material, as is the case when electrodes are simply brought down in contact with the surface of the material. It also requires much less power and a shorter time to make the weld. Still another modification of this method is shown at *B*. Here one piece has a hole drilled in it and the other is provided with a projection. This still further decreases the amount of power required to make the weld. The method shown at *C* is similar to that at *A* with the exception that only one piece is provided with a hole. The method shown at *D* illustrates the method of welding a small cup to a larger one. In this case it will be noticed that the large cup is provided with a hole for localizing the current.

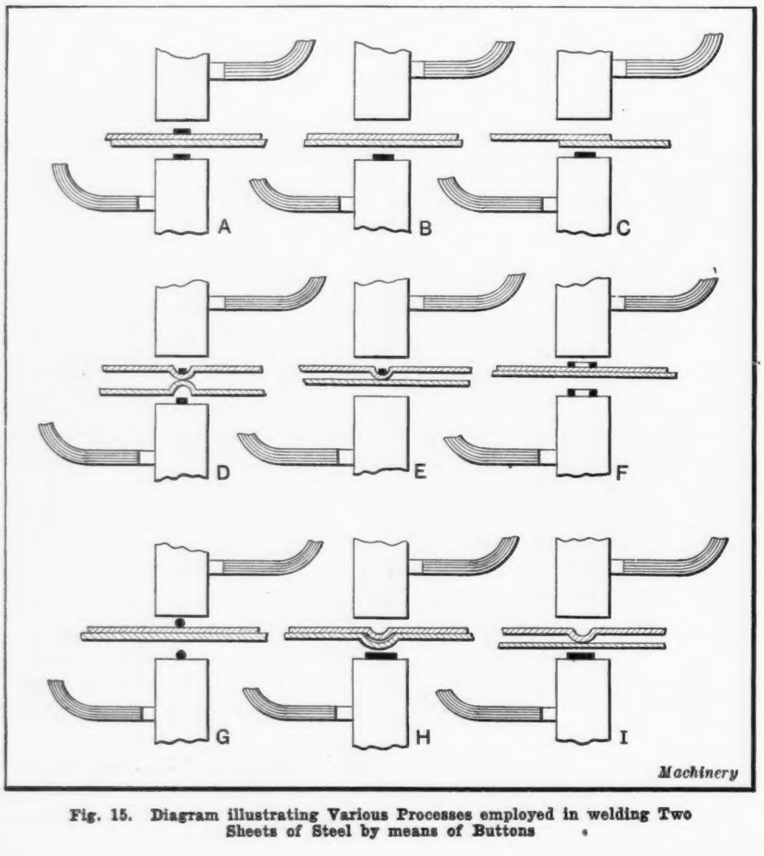


Fig. 15. Diagram illustrating Various Processes employed in welding Two Sheets of Steel by means of Buttons

Welding Thick to Thin Metal

Little difficulty is experienced in welding two pieces of sheet steel of the same thickness, but when the thicknesses of the two parts to be welded are unequal, difficulty is sometimes encountered in obtaining a perfect junction. The reason for this is that the thin sheet heats up much quicker than the thicker one and is burned before the thick sheet reaches a welding temperature. One method of satisfactorily welding a thick sheet to a thin one is shown at *A* and *B* in Fig. 8. In order to prepare the thicker piece to be welded to the thinner one, a point or projection is formed on the lower surface of the thick piece. This localizes the current, and both pieces—thick and thin—heat up at the same time, so that when pressure is applied a perfect junction can be made.

Welding Thick Work

As has been previously stated, the limit of spot-welding practice is reached when the pressure necessary to bring the sheets of metal into intimate contact is such that upsetting of the copper electrodes takes place. *C* and *D* in Fig. 8 show a method of applying mechanical means for effecting a contact between the two sheets to be welded. The hardened steel sleeve *a* is connected up by a toggle mechanism to a hydraulic or air cylinder. To effect the weld, the pressure is then applied and the hardened steel sleeve is brought down in contact with the surface of the sheets, pressing them against a lower electrode which preferably should be made from either a large block of copper or a similar mechanism to the upper electrode. When the sheets have been brought down into intimate contact, the current is turned on, and as the electrode is held in contact with the sheet by means of a very stiff spring, the pressure exerted by the electrode is sufficient to fuse the sheets together when they reach the proper temperature.

A practical application of this principle in which the steel dies are dispensed with is shown in Fig. 7. In this case large copper electrodes—the upper one 2½ and the lower one 3 inches diameter—are used to both heat and press the metal together. This machine which has a capacity for welding two strips 1¼ inch thick exerts 50 tons, and is operated hydraulically. The slide carrying the upper electrode is operated through a toggle-joint, receiving power from a hydraulic ram. The maximum capacity is 100 kilowatts.

Point- or Projection-welding

There are numerous applications of point- or projection-welding which can be accomplished on an

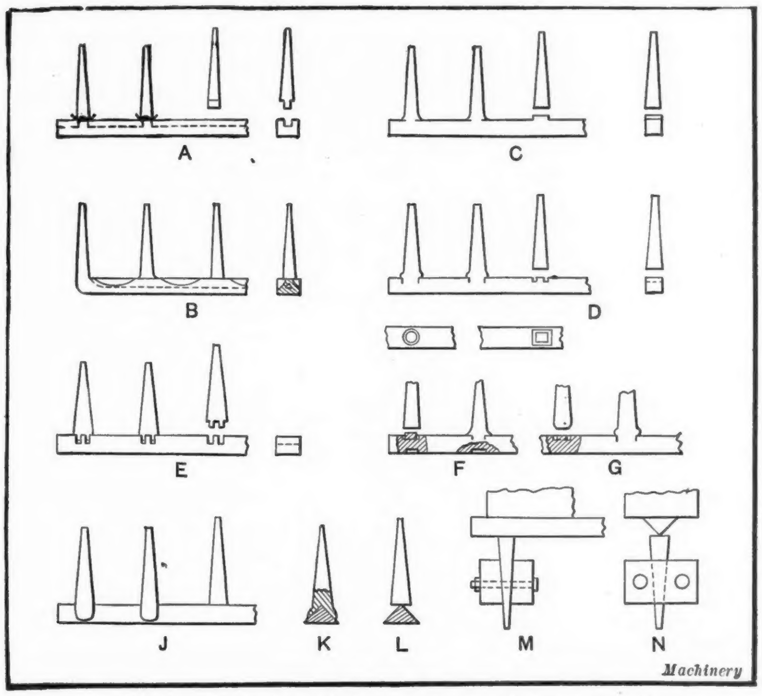


Fig. 17. Diagram illustrating Principles used in employing Process known as "T-welding" with Special Application to the Manufacture of Garden Rakes

electric spot-welding machine. The example shown at *A* in Fig 8 illustrates one of the simplest processes employed. Fig. 12 shows a process which is not as well known, and which has remarkable possibilities. By the ordinary method of performing electric spot-welding operations, it is impossible to join two hardened pieces without drawing the temper. There are cases, however, where it is desirable to secure a good weld without drawing the temper, the magnet bars used in a telephone receiver being an example in point.

Those familiar with this work know that magnet bars in telephone transmitters should be as permanent as possible, and for this reason a special material known as magnet steel is used; this is hardened to a glass hardness. Formerly difficulty was encountered in joining the two bars of the magnet, because of the extreme hardness of the pieces. The method generally employed was to drill holes through each end of the magnet and through the spacing keeper and then rivet the members together. This method had the serious objection that in riveting the pieces together it was difficult to avoid breaking the magnets owing to their extreme hardness, so that a considerable percentage of magnets were spoiled during the final riveting operation.

Electric welding has greatly simplified this problem by uniting the three pieces rigidly without drawing the temper of the magnets. The manner in which this is accomplished is interesting. The spacing bar as shown at *a* in Fig. 12 is provided with knife-shaped circular ridges about 1/64 inch high. The pieces are then assembled in a fixture to hold them in the proper position and placed between the electrodes of a spot-welding machine especially fitted up to provide an amperage of about 2000 amperes. The electrodes are then brought in contact with the work, the current turned on and the weld made in a fraction of a second. So rapidly is the weld made that the metal is not annealed; it does not have time to heat up except at the knife edge point where the weld is actually made. Practically no flash is formed and the pieces are rigidly united.

Multiple Point- or Projection-welding

In electric welding comparatively large pieces of thin metal where it is desirable to have the pieces lie in close proximity to each other, the multiple point or projection method of welding can be employed with success. Some of the processes employed for this purpose are illustrated in Fig. 9. *A* shows a case where one sheet only is provided with projections; *B* where two sheets are provided with projections; *C* where projections are formed into the sheet by milling it away; *D* where projections are formed in both sheets in a similar manner; *E* where the button method is employed; and *F* where three sheets are being united. The disadvantages of the button method are that it is difficult to locate the buttons in the correct position to each other, and it is much slower than the other processes. Of course, it requires no special preparation of the material previous to welding.

A modification of the principle illustrated at the left-hand side of Fig. 9 is shown on the right-hand side of the same illustration. In this case, instead of using long, flat electrodes, a series of electrodes are employed. This process applies particularly to the manufacture of sheet steel radiators. *G* shows how the metal is prepared with points for welding and *H* shows the result of the weld. *I* is a modification of the process in which only one sheet is provided with projections.

Multiple Electrode Welding

In Fig. 11 is an application of what might be called multiple point- or projection-welding. In this case it is desirable to weld a number of pins to a sheet, and as these pins generally vary in length, provision must be made for taking care of this discrepancy so that all pins will contact at the same time. The diagram illustrates the principle of the machine designed for this purpose. The pins are located in a plate *A* which acts as a cooling agent for conducting away the heat, and is supported and insulated, as shown. The pins rest in small cup-shaped grooves in the lower electrodes which, as will be seen, are spring mounted so as to take care of any variation in the thickness of the metal and the length of the pins. It will be noticed that the two side electrodes are swung from a fulcrum point, whereas the center electrode as shown in the sectional view to the right is in the form of a slide.

The diagram shown in Fig. 16 illustrates several methods of supplying current from the same transformer secondary to several pieces engaging electrodes in such a manner that the same heating effect is produced in all the pieces on which the electrodes contact. In the case shown at *A* the secondary of the transformer is composed of a heavy copper casting *a*, whereas *b* is the primary and *c* the laminated iron core. The

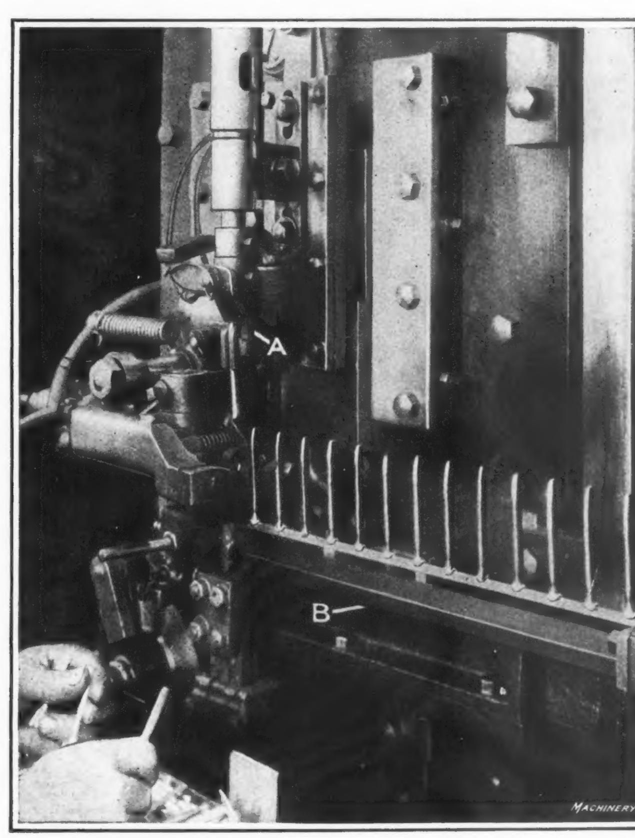


Fig. 18. Semi-automatic Machine built by the National Electric Welder Co. for welding Garden Rakes

terminals d and e of the secondary extend in opposite directions, so that the difference of potential across any pair of electrodes is the same. This will be made more clear by referring to the diagram shown at *B*. Here the terminal bars extend in the same direction, and one of them f forms the terminal of a secondary circuit which is partially returned upon itself. In such a construction, a difference of potential exists across each pair of electrodes.

The diagram shown at *C* illustrates the application of two primaries or sets of primary coils which act upon the same secondary bar or casting in such a manner as to give an increased potential across the bars due to the fact that the electro-motive forces set up in the secondary by the primary act in series to reinforce one another. In this case two laminated cores can also be used to advantage. By arranging the current carrying the secondary bars in this manner, an equal potential force is obtained, so that a satisfactory weld can be made by each of the individual electrodes. *D* and *E* show a diagram of an automatic welding machine incorporating the multi-electrode principle shown at C.

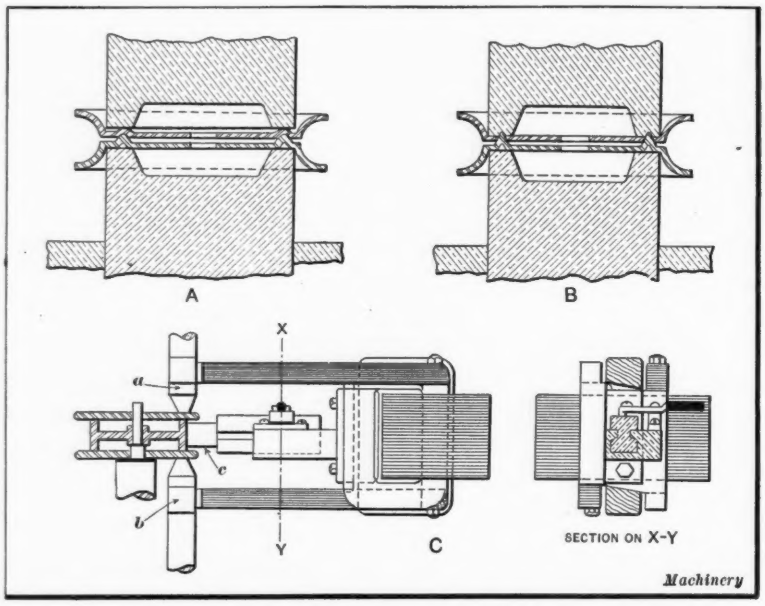


Fig. 19. Diagram illustrating Various Processes employed in the Manufacture of Sheaves or Pulleys

Ridge-welding

Ridge-welding is that process of electric welding which makes use of the principle of forming ridges on the work and then generally placing these ridges at right angles to each other, forming a cross at the point where the weld is made. This junction of the two pieces localizes the heat directly in line with the axis of the electrodes, and makes rapid welding possible. Two examples of this class of work are shown in Fig. 13. Example *A* shows a rod being welded to a narrow strip provided with a ridge in the center. In this case the circumference or arc on the rod acts in the same manner as a ridge, and by turning on the current and applying pressure these two pieces can be homogeneously united, as shown at *B*. Another method which makes use of two strips, both of which are provided with ridges, is shown at *C*. The action of welding these two pieces together is almost similar to that previously described, the finished weld being shown at *D*.

Button-welding

Another welding process which has been used with satisfactory results is that known as button-welding. In addition to many other uses, this can be applied to the welding of very thick work which it would be impossible to spot-weld because of the fact that the metal could not be brought into close contact without applying enormous pressure. By this method a button of metal of the same material as that being welded is placed on the top or bottom electrode or on both, as the case may be; then the two pieces to be welded are placed between these buttons and pressure is applied on top of the button. The current is then turned on and the buttons localize the current, resulting in the metal being fused at the point where the buttons are located, and when pressure is applied the partially molten buttons are then forced through the already molten metal and a perfect junction is made. Several process applications are shown in Fig. 15: *A* shows one method where two buttons are used; *B*, one button; *C*, a case where one button is used to perform a lap-weld; *D*, a combination of button- and point-welding; this is a special process and is seldom used; *E*, a case where a point and one button is used; and *F*, buttons in the form of rings. The example shown at *G* is one in which pieces of wire are employed in the place of flat buttons; *H* is a case where the two pieces are provided with projections fitting in each other and a button used in addition; *I* represents a somewhat similar case to that shown at *H*. All of these processes have not been used in practice, but represent possibilities of electric welding.

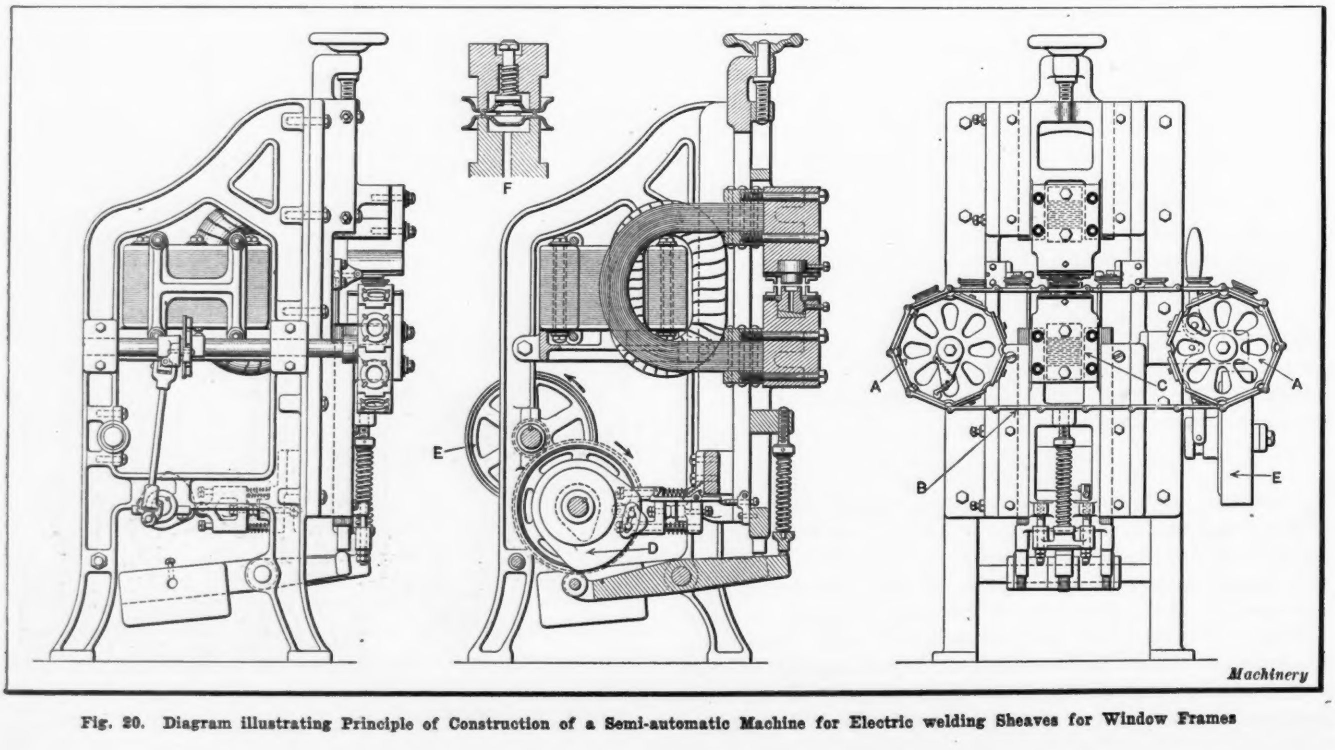


Fig. 20. Diagram illustrating Principle of Construction of a Semi-automatic Machine for Electric welding Sheaves for Window Frames

Bridge- or Tie-welding

When it is desired to unite two narrow strips so that their ends abutt without overlapping, this can be accomplished by the process known as bridge- or tie-welding. Several applications of this process are illustrated in Fig. 14. One process illustrated at *A* consists in using a number of small flat washers, all of which lie in the same plane and are superimposed on the plates to be welded, making contact therewith. When the current is turned on and pressure applied, these pieces are fused, and make a junction point between the two strips of metal, leaving practically little or no burr. *B* shows a slight modification of this process, using solid strips instead of washers; *C* is a combination of bridge- and point-welding, the bridge being provided with projections which localize the current and effect quick heating. This process does not give as solid a junction as those previously described. A similar process is shown at *D* which has the same objection. *E* is still another process which, while it effects a junction between the two pieces, does not give a strong joint. *F* is a somewhat similar process to *D*, employing two bridges instead of one, which has the same objection as the processes illustrated at *C* and *D*.

T-welding

A process of electric welding which has a wide application in the agricultural field is known as T-welding. This process is used to special advantage in the manufacture of garden rakes and, as shown in Fig. 17, has many modifications. At *A* is shown one method of effecting a weld. The top part of the rake is provided with a slot running its entire length, and the tangs which are welded to it are provided with projections fitting in this slot. These tangs are then satisfactorily welded to the frame under a spot-welding machine. Still another method is shown at *B*. In this case the current is localized by providing points by milling away the sides of the top of the rake. *C* shows still another method. Here the outside of the rake is provided with projections of an area equal to the lower end of the tang, so as to equalize the heating effect of the current on the parts welded.

The method shown at *D* is somewhat similar with the exception that the projection is formed by milling two small slots across the face of the top part of the rake. A method which is just the reverse of that shown at *D* is shown at *E*. Here both pieces are provided with projections, forming a matched joint. *F* and *G* show still other methods which are limited in their application because of the difficulty of making the required projections. The methods shown at *J*, *K* and *L* illustrate the preparation of the work for welding and the finished welded work, *L* showing how the weld is started and *J* and *K* the form of the weld. *M* and *N* show two views illustrating how the electrodes are applied to the work to perform a weld as shown at *J*, *K* and *L*, respectively.

A practical application of this process of welding is shown in Fig. 18. In this case the tangs of the rake are made from 1/4-inch round steel rods, which are welded to a triangular back 1/4 by 7/16 inch. There are fourteen teeth in each rake and one operator produces 375 rakes in nine hours, or in other words, he makes 5250 welds in this time. In operating this machine, the tangs are placed in the solenoid *A* and the back is placed on slide *B*; the machine then automatically spaces the tangs, sets and welds them to the back at the rate previously mentioned.

Sheave Welding

A class of work in which the point or projection method of electric welding is used to good advantage is the manufacture of sheaves for window sashes. Two methods of applying this process are illustrated diagrammatically at *A* and *B* in Fig. 19. In the example shown at *A*, the two halves of the sheaves are prepared with projections which fit into each other, whereas in the case shown at *B* one piece or half is provided with a projection and the other with a hole to receive it. Usually this work is carried on in a semi-automatic manner, and a special machine has been designed for this work as illustrated in Figs. 20 and 21. Referring to Fig. 20, it will be noticed that the machine is provided with two drums *A* on which an endless chain *B* is carried. These drums are rotated through suitable mechanism, being indexed around to bring the pair of sheaves to be welded in line with the welding electrodes. The sheaves remain in line with the welding electrodes for a sufficient length of time for the weld to be effected. The various timing mechanisms on the machine as well as the movement of the lower electrode slide *C* is controlled by cam *D* driven by gears from a main driving pulley *E*. A different electrode mechanism from that shown attached to the machine is shown in the same illustration at *F*. In this case it will be noticed that the upper electrode is provided with a spring-operated pad having a non-conductive surface. This is used to prevent the work from bulging in the center when the pressure is being applied to effect a weld. The production of the machine shown in Figs. 20 and 21 is 15,000 sheaves in ten hours.

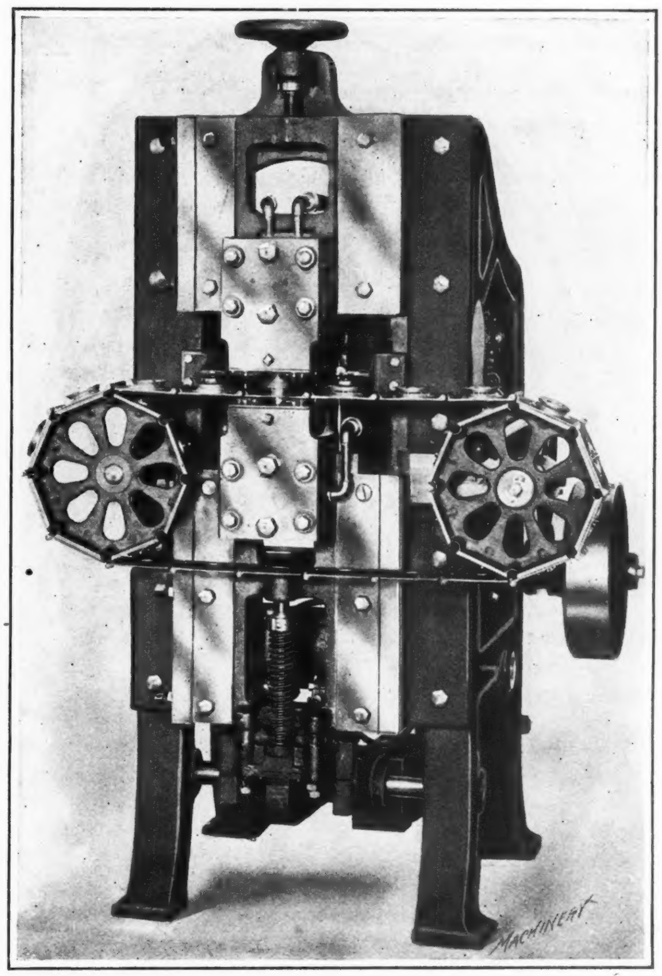


Fig. 21. Special Electric Seam Welding Machine built by the Universal Electric Welder Co.

The diagram shown at *C* in Fig. 19 illustrates a method of welding sheaves or small pulleys employing three contacting electrodes. This employs a single transformer which permits of making more than one weld simultaneously and in which there is an even distribution of current to each weld. The secondary consists of three terminals, *a*, *b* and *c*, one of which *c* is common to the other two and disposed equidistantly between them, so that there will be at all times an equal distribution of the electric current through the secondary to the welding terminals. A third terminal may be connected to the turns at the connection between them, so that there is a turn between the terminals at both ends of the secondary, and the third terminal in this case will have two volts between this and the other two. By using an apparatus of this kind, it is possible, as is clearly seen, to confine the heating to the contacting surfaces of the work. The upper edges of the interposed electrodes, of course, conduct the current to the junction of the plate and the center of the sheave in such a manner that the core or center is not heated except on its contacting surfaces with the plate. In this way a satisfactory weld can be easily effected.

LAYING OUT SKEW BEVEL GEARS*

THE TWO PRINCIPAL TYPES OF SKEW BEVEL GEARS, THEORY OF THEIR DESIGN AND METHODS OF CUTTING TEETH

BY REGINALD TRAUTSCHOLD†

ONE excellent type of gear—the skew bevel—has been generally avoided by both designers and machinists: by the former on account of the difficulty experienced in laying it out, and by the latter because of a fancied intricacy in the method of cutting. The development of bevel gear generators, as well as greater familiarity on the part of the machinist with processes of milling and planing gear teeth, have gone a long way toward removing his antipathy for the skew bevel gear. There remains, however, the dislike of the designer as an explanation of the continued unpopularity of this gear, which is also due in part to a slightly greater cost of manufacture than that of the ordinary bevel gear.

The shaft axes of skew bevel gears do not lie in a common plane, and the various face and cutting angles do not converge to a common apex; in place of a single apex, there is a circle of apexes, so that accurate mathematical calculations of the various angles are complicated and involved. This constitutes the basis for the dislike of skew bevel gears on the part of the designer. However, very close approximations of the true angles and diameters can be arrived at by the use of simple formulas, and these approximations are as reliable from the practical working point of view of the shop as if the exact measurements were actually furnished, which would indeed involve complicated calculations. The conditions governing the obliquity of skew bevel gear teeth and the various diameters and angles are, in reality, quite simple; and when the basic principles have once been grasped by the designer, the lay-out of a skew bevel gear combination presents little more difficulty than that of an ordinary bevel gear.

There are two general types of skew bevel gears, which, for the sake of brevity, may be referred to as Types A and B. In the former a pinion of the ordinary bevel gear type is employed, the oblique teeth being confined to the gear, and in the latter the teeth are oblique in both pinion and gear. In each type, the pitch surface of the pinion is the frustum of a figure generated by the revolution of a straight line about the axis of the figure, the generating line lying in a plane parallel to a plane through the axis, and being neither parallel nor at right angles to the axis, *i. e.*, the figure is a hyperboloid of revolution.

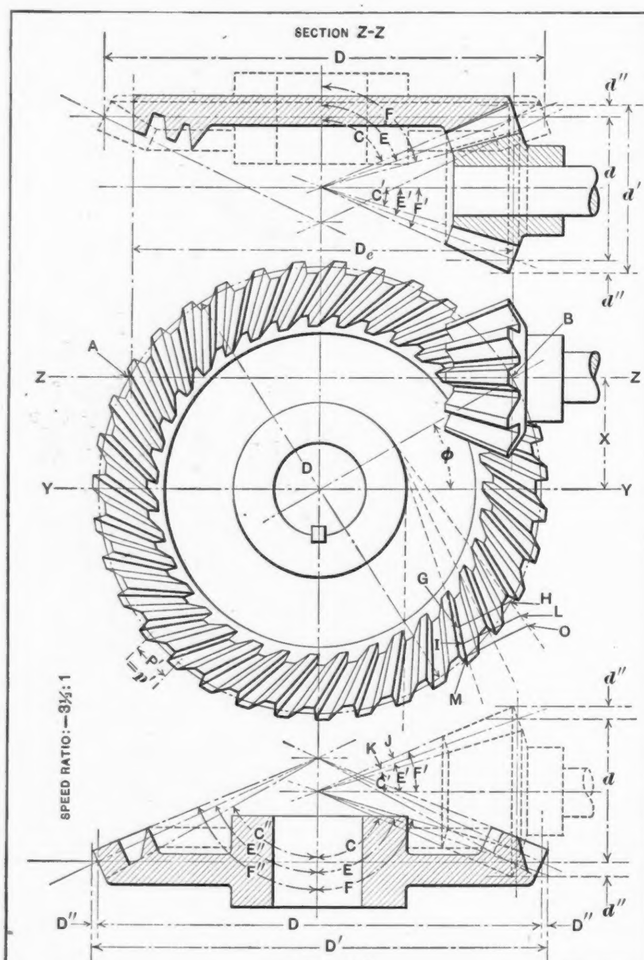


Fig. 1. Diagram showing Principles involved in Lay-out of Type A Skew Bevel Gears, in which Ordinary Bevel Pinion meshes with Skew Bevel Gear

Skew Bevel Gears—Type A

Taking up first the design of skew bevel gears designated as Type A, a typical lay-out is shown in Fig. 1, where the dimension X indicates the offset of the pinion shaft. It will be evident that the profile planes of the gear tooth actually in mesh with the pinion converge to the apex point, the pinion differing in no respect from an ordinary bevel gear having a center angle E'. As the gear revolves, the profile planes of each succeeding tooth must also converge to this same point, so that the gear really has a circle of apex points, having a diameter equal to twice the offset of the pinion shaft, instead of a common apex point as in the case of an ordinary bevel gear combination.

If it were not for the offset of the pinion shaft, the pitch diameter of the gear meshing with the equivalent pinion would equal AB, and no difficulty would be encountered in ascertaining the number of teeth, etc., required for both the gear and the pinion, the speed ratio and pitch of the combination being known. The pinion of the Type A skew bevel gear combination differs in no way, as far as pitch and number of teeth are concerned, from such requirements for an ordinary bevel gear combination of the same ratio, but the angles of the pinion and possibly its face width differ. The number of teeth in the gear must remain the same as that required for an ordinary bevel gear of pitch diameter AB, in order that the speed ratio of the combination may not vary, and the normal pitch of the skew bevel gear must conform to the circular pitch of the pinion with which it is to run. The actual pitch diameter of the skew bevel gear is considerably greater than its "equivalent pitch diameter," AB, but the number of teeth and their proportions remain the same, due to their obliquity. This is the secret of skew bevel gears, and it is failure to recognize this simple fact that has led to the common belief that skew bevel gears are difficult to design.

As the oblique teeth of the gear come in contact with the radial teeth of the pinion in this style of skew bevel gear combination, a certain sliding action takes place. Referring to Fig. 1 and the pitch lines of the gear and pinion, the outer end of the pinion tooth first comes into contact with its mating gear tooth at point G and contact ceases with the outer end of the pinion tooth in contact with the gear at point M, *i. e.*, the end of the pinion tooth has slid on the gear tooth from G to M, which is equal to the distance HO. This sliding action is accentuated by any increase in the obliquity of the gear teeth, which, in turn, varies with the amount of pinion shaft offset. The normal pitch of the gear IL obviously must conform to the circular pitch of the pinion, while the circular pitch of the gear MH is considerably greater than the circular pitch of the pinion.

The various angles and tooth proportions of the pinion are the same as those of any ordinary bevel gear of the same number of teeth, pitch, etc., and of similar center angle; and they are easily calculated by the use of the familiar formulas for such gears. The calculations involved in laying out skew

* For other articles on the subject of skew bevel gearing published in MACHINERY, see "Generating the Skew Bevel Gear," March, 1913; "A Practical Form of Tooth for Skew Bevel Gears," January, 1913; and "The Skew Bevel Gear Model," January, 1907.

† Address: 39 Charles St., New York City.

bevel gears require the use of somewhat different formulas, as given in the following, the derivation of which will be explained subsequently.

Notation for Skew Bevel Gears—Type A

p = diametral pitch;
n = number of teeth in pinion;
N = number of teeth in gear;
X = offset of pinion shaft;
ϕ = angle of offset;
d = pitch diameter of pinion;
D_e = equivalent pitch diameter of gear;
D = pitch diameter of gear;
d' = outside diameter of pinion;
D' = outside diameter of gear;
p' = circular pitch of pinion;
P' = circular pitch of gear;
E' = center angle of pinion;
F' = face angle of pinion;
C' = cutting angle of pinion;
E = center angle of gear (shop angle);
F = face angle of gear (shop angle);
C = cutting angle of gear (shop angle);
E'' = center angle of gear (design angle);
F'' = face angle of gear (design angle);
C'' = cutting angle of gear (design angle);
J = angle increment of pinion;
K = angle decrement of pinion;
d'' = diameter increment of pinion;
D'' = diameter increment of gear;
s = addendum.

Formulas for Skew Bevel Gears—Type A

$$d = \frac{n}{p} \tag{1}$$

$$D_e = \frac{N}{p} \tag{2}$$

$$\tan \phi = \frac{2X}{D_e} \tag{3}$$

$$D = \frac{2X}{\sin \phi} \tag{4}$$

$$P' = \frac{3.1416D}{N} \tag{5}$$

$$\tan E' = \frac{d}{D_e} \tag{6}$$

$$\tan J = \frac{2 \sin E'}{n} \tag{7}$$

$$\tan K = \frac{2.314 \sin E'}{n} \tag{8}$$

$$F' = E' + J \tag{9}$$

$$C' = E' - K \tag{10}$$

$$s = \frac{d}{n} = \frac{D}{N} \tag{11}$$

$$d'' = s \cos E' \tag{12}$$

$$d' = d + 2d'' \tag{13}$$

$$E = 90 - E' \text{ (shop angle)} \tag{14}$$

$$\tan E'' = \frac{D - 2X}{d} \text{ (design angle)} \tag{14 a}$$

$$D'' = s \cos E \tag{15}$$

$$D' = D + 2D'' \tag{16}$$

or for greater accuracy:

$$D' = D + \frac{2D''D_e}{D}$$

$$C = E - K \text{ (shop angle)} \tag{17}$$

$$C'' = E'' - \frac{KD_e}{D} \text{ (design angle)} \tag{17 a}$$

$$F = E + J \text{ (shop angle)} \tag{18}$$

$$F'' = E'' + \frac{JD_e}{D} \text{ (design angle)} \tag{18 a}$$

Derivation of Foregoing Formulas

The formulas applying to the dimensions and angles of the pinion are similar to those for any ordinary bevel gear, when the center angle of the pinion has once been ascertained.

The equivalent pitch diameter D_e of the gear is equal to the number of gear teeth N divided by the diametral pitch p.

The angle of offset ϕ is the angle formed by the intersection of a horizontal plane with a vertical plane through the axis of the gear shaft parallel to the pinion shaft and a vertical plane through the gear shaft axis and point B of tangency of the pitch circles of the gear and pinion. Tangent ϕ equals the offset X of the pinion shaft divided by half the equivalent pitch diameter D_e of the gear, or twice the offset X of the pinion shaft divided by the equivalent pitch diameter D_e of the gear.

The pitch diameter D of the gear is then equal to twice the pinion shaft offset X divided by the sine of the angle of offset ϕ.

The circular pitch P' of the gear is equal to the quotient of its pitch circumference πD divided by the number of teeth N.

The tangent of center angle E' of the pinion is the quotient of the pitch diameter d of the pinion divided by the equivalent pitch diameter D_e of the gear.

The ordinary method of arriving at the outside diameter D' of a bevel gear by adding to its pitch diameter D twice the diameter increment D'' may also be used in the case of skew bevel gears when the pinion offset X is slight, but this method is not quite accurate on account of the obliquity of the teeth. The greater the pinion shaft offset the smaller, proportionally, does the diameter increment of the gear become, and so the second formula for ascertaining the outside diameter of the gear, which is based on the arbitrary assumption that the decrease in diameter increment is proportional to the ratio of the equivalent pitch diameter D_e of the gear to the actual pitch diameter, is more reliable. This relationship is not quite accurate either, but any possible error which might arise would be so slight as to be quite immaterial from a practical standpoint.

The various angles of the skew bevel gear evidently depend upon the point from which they are viewed. The tooth profile planes all converge to the circle of apexes, fixed by the pinion shaft offset X. If, therefore, the angles are measured on such a profile on lines conforming to the obliquity of the teeth, it is evident that they will differ from similar angles measured on such planes, but on lines converging to a common point, *i. e.*, the apex of the imaginary cone of which the figure bounded by the pitch circle of the gear and the circle of apexes forms a frustum. The former set of angles, *i. e.*, those measured to the circle of apexes, and therefore normal to the pitch circle of the gear, may then be referred to as "shop angles," as they are employed in machining the gears; and the latter set of angles, *i. e.*, those measured on lines converging to the apex of the imaginary cone, are known as "design angles," for they are useful in designing the gears and the patterns for the blanks.

The shop center angle E is evidently the complement of the center angle E' of the pinion, for each tooth of the gear must mesh exactly with the pinion teeth on the line of contact. The design center angle E'' of the gear is naturally half the apex angle of the imaginary cone, of which a frustum would be the figure having its larger base diameter equal to the pitch diameter D of the gear, its smaller base diameter equal to twice the pinion shaft offset X, and a height equal to half the pitch diameter d of the pinion. The tangent of half this apex angle of the imaginary cone reduces to the equation given as Formula (14 a). This angle is somewhat smaller, the amount depending upon the pinion shaft offset, than the complement of the center angle E' of the pinion, the shop center angle of the gear.

The shop cutting and face angles C and F of the gear are evidently ascertained in a manner similar to that employed for arriving at such angles for an ordinary bevel gear, *i. e.*, by subtracting the angle decrement in one case and adding the angle increment in the other, from and to the shop center angle, respectively. To arrive at the design cutting and face angles C and F of the gear, however, the fact that both the angle increment and the angle decrement of the gear are af-

fected by the offset X of the pinion shaft must be taken into consideration, so that subtracting and adding these angles to the design center angle E'' of the gear would not give the true design cutting and face angles. The actual decrement and increment design angles are so small, however, that such respective angles of the pinion modified by multiplication by the ratio of the equivalent pitch diameter D_e of the gear to its pitch diameter D may be taken as measuring the true decrement and increment design angles for all practical purposes. Such modifications are based on the assumption that the decrease in the respective design angles is proportional to the amount of pinion offset and are included in Formulas (17 a) and (18 a).

Example in Design of Skew Bevel Gears—Type A

Example.—Required: A pair of skew bevel gears, 8 diametral pitch, 96 teeth in gear, 20 teeth in pinion; pinion shaft offset 3 inches.

Pitch diameter d of pinion:

$$d = \frac{20}{8} = 2.50 \text{ inches} \tag{1}$$

Equivalent pitch diameter D_e of gear:

$$D_e = \frac{96}{8} = 12 \text{ inches} \tag{2}$$

Angle of offset ϕ:

$$\tan\phi = \frac{2 \times 3}{12} = 0.5000 \tag{3}$$

$$\phi = 26 \text{ degrees, } 34 \text{ minutes}$$

Pitch diameter D of gear:

$$D = \frac{2 \times 3}{0.4472} = 13.41 \text{ inches} \tag{4}$$

Circular pitch P' of gear:

$$P' = \frac{3.1416 \times 13.41}{96} = 0.4388 \text{ inch} \tag{5}$$

Center angle E' of pinion:

$$\tan E' = \frac{2.50}{12} = 0.2083 \tag{6}$$

$$E' = 11 \text{ degrees, } 46 \text{ minutes}$$

Angle increment J of pinion:

$$\tan J = \frac{2 \times 0.2039}{20} = 0.0204 \tag{7}$$

$$J = 1 \text{ degree, } 10 \text{ minutes}$$

Angle decrement K of pinion:

$$\tan K = \frac{2.314 \times 0.2039}{20} = 0.0236 \tag{8}$$

$$K = 1 \text{ degree, } 21 \text{ minutes}$$

Face angle F' of pinion:

$$F' = 11 \text{ deg., } 46 \text{ min.} + 1 \text{ deg., } 10 \text{ min.} = 12 \text{ deg., } 56 \text{ min.} \tag{9}$$

Cutting angle C' of pinion:

$$C' = 11 \text{ deg., } 46 \text{ min.} - 1 \text{ deg., } 21 \text{ min.} = 10 \text{ deg., } 25 \text{ min.} \tag{10}$$

Addendums:

$$s = \frac{2.50}{20} = 0.125 \text{ inch} \tag{11}$$

Diameter increment d'' of pinion:

$$d'' = 0.125 \times 0.9790 = 0.1227 \text{ inch} \tag{12}$$

Outside diameter d' of pinion:

$$d' = 2.50 + (2 \times 0.1227) = 2.7454 \text{ inches} \tag{13}$$

Center angle of gear, E "shop" and E'' "design":

$$E = 90 - 11 \text{ deg., } 46 \text{ min.} = 78 \text{ deg., } 14 \text{ min. (shop angle)} \tag{14}$$

$$\tan E'' = \frac{13.41 - (2 \times 3)}{2.50} = 2.9640 \tag{14 a}$$

$$E'' = 71 \text{ degrees, } 21 \text{ minutes (design angle)}$$

Diameter increment D'' of gear:

$$D'' = 0.125 \times 0.2039 = 0.0255 \text{ inch} \tag{15}$$

Outside diameter D' of gear:

$$D' = 13.41 + (2 \times 0.0255) = 13.461 \text{ inches} \tag{16}$$

or for greater accuracy:

$$D' = 13.41 + \frac{2 \times 0.0255 \times 12}{13.41} = 13.4556 \text{ inches,}$$

or, say, 13.46 inches

Cutting angle of gear:

$$C = 78 \text{ deg., } 14 \text{ min.} - 1 \text{ deg., } 21 \text{ min.} = 76 \text{ deg., } 53 \text{ min. (shop angle)} \tag{17}$$

$$C'' = 71 \text{ deg., } 21 \text{ min.} - \frac{1 \text{ deg., } 21 \text{ min.} \times 12}{13.41} = 70 \text{ deg., } 9 \text{ min. (design angle)} \tag{17 a}$$

Face angle of gear:

$$F = 78 \text{ deg., } 14 \text{ min.} + 1 \text{ deg., } 10 \text{ min.} = 79 \text{ deg., } 24 \text{ min. (shop angle)} \tag{18}$$

$$F'' = 71 \text{ deg., } 21 \text{ min.} + \frac{1 \text{ deg., } 10 \text{ min.} \times 12}{13.41} = 72 \text{ deg., } 24 \text{ minutes (design angle)} \tag{18 a}$$

Cutting Skew Bevel Gears—Type A

Skew bevel gears are, in reality, very little more difficult to cut than bevel gears of the ordinary type, but the distinction between the shop angles and design angles must be kept in mind. Any machine suitable for cutting ordinary bevel gears can be employed in cutting skew bevel gears by making simple adjustments or modifications of the machine. The pinion of type A skew bevel gears is cut just like any ordinary bevel gear; and it is only in the case of the skew bevel gear that the special machine adjustments are necessary. The gear blank is usually turned to the required design face angle in a lathe, and it is then mounted on the spindle of the machine employed for cutting the teeth. The spindle of this machine must be offset from the plane of travel of the cutting tool, the cutting tool being dropped a distance X equal to the offset of the pinion shaft; and the path of the cutting tool must conform to the normal profile planes of the gear teeth. That is, the cutting tool must reproduce the action of the engaging pinion tooth in the contact plane in which the pinion and gear mesh.

Subsequent operations are then similar to those employed in cutting ordinary bevel gears, except that the path of the cutting tool is always tangent to the gear's circle of apexes,

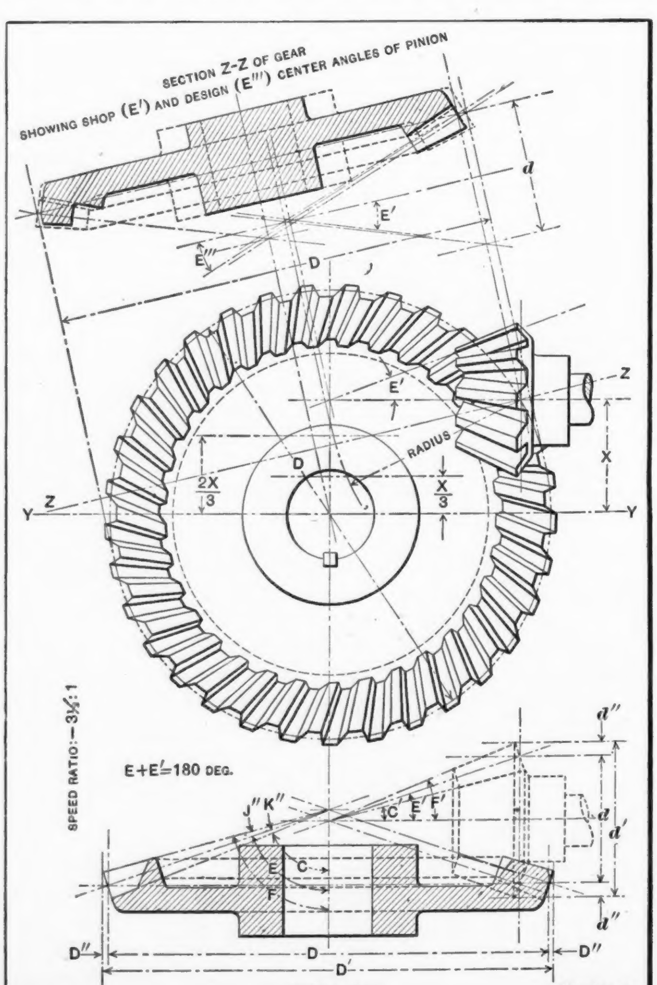


Fig. 2. Diagram showing Principles involved in Lay-out of Type B Skew Bevel Gears, in which both Gear and Pinion have Skew Teeth

represented by the amount of spindle offset, so that the shop angles must be employed and not the design angles. The adjustments of the gear blank are controlled by the circular pitch of the gear, not its normal pitch which conforms to the circular pitch of the pinion. When the rough gear blank is placed on the spindle of the finishing machine to avoid the preliminary operation of facing the blank in a lathe or other machine, the shop face angle is employed, not the design face angle. This practice is not to be commended, however, for the gear-tooth cutting machine is an expensive and sensitive one, so that it usually pays to perform the rough-facing operation on a more rugged machine.

Skew Bevel Gears—Type B

The second type of skew bevel gear is illustrated in Fig. 2, and although apparently more complicated than the type which has been described, it is more easily laid out—at least, the calculations required are simpler—if this type of gear is not less complicated to machine. The teeth in both the gear and pinion being cut askew, the cutting of such gears is greatly simplified by making the obliquity of the teeth the same in both pinion and gear. The obliquity of the teeth being the same in the two gears, the center angles of the pitch surfaces are supplements of each other—see Fig. 2—and are very nearly the same as the true center angles of the respective gears, the latter being slightly greater. The close similarity between the pitch surface center angles and the true center angles of the gears has led to the common practice of employing the same formulas for the angles of type B skew bevel gears as are used for ordinary bevel gears, and of making all proportions of such gears the same as those of ordinary bevels of the same pitch, number of teeth and ratio. This practice has the advantage of involving only calculations with which every gear designer is familiar, but it is nevertheless incorrect. The angles are practically the same, it is true, but the diameters of skew bevel gears should be somewhat greater than those of similar plain bevel gears on account of the obliquity of the teeth—that is, if the full strength of the teeth is to be realized.

The obliquity of the teeth being equal in the two gears, the circles of apexes are proportional to the speed ratio of the gears. That is, the radius of the respective circles of apexes is not equal to the total offset of the pinion shaft, as is the case in type A skew bevel gears where the obliquity of teeth is confined to the gear; but the radius of the circle of apexes for each gear is proportional to its diameter, the sum of the two radii equaling the total offset. For instance, in a pair of skew bevel gears of this type in which the pinion shaft offset is 3 inches and the speed or diameter ratio 3 to 1, the radius for the apex circle of the pinion would be $3 \times \frac{1}{4} = 0.75$ inch, and for the gear $3 \times \frac{3}{4} = 2.25$ inches. Though the formulas for the design of type *B* skew bevel gears are much the same as the well-known formulas for ordinary bevel gears, their insertion here is necessary for a comprehensive understanding of the skew bevel gear principle of teeth of equal obliquity in the two gears, even assuming the various angles to be the same as those for similar ordinary bevel gears.

Notation for Skew Bevel Gears—Type B

The notation is the same as that for type A gears with the following additions:

V = radius of circle of apexes for pinion;
W = radius of circle of apexes for gear;
X = total offset of pinion shaft $= V + W$;
y = angle of offset for pinion;
z = angle of offset for gear;
R = speed ratio $= N/n$;
J'' = angle increment;
K'' = angle decrement;
P'' = circular pitch;
d_e = equivalent pitch diameter of pinion.

Formulas for Skew Bevel Gears—Type B

$$V = \frac{X}{R+1} \quad (1)$$

$$W = RV \quad (2)$$

$$D_e = \frac{N}{p} \quad (3)$$

$$\tan y = \frac{2V}{D_e} \quad (4)$$

$$D = \frac{2V}{\sin y} \quad (5)$$

$$d = \frac{Dn}{N} \quad (6)$$

$$P'' = \frac{3.1416d}{n} = \frac{3.1416D}{N} \quad (7)$$

$$\tan E' = \frac{d}{D} \quad (8)$$

$$E = 90 - E' \quad (9)$$

$$\tan J'' = \frac{2 \sin E'}{n} \quad (10)$$

$$\tan K'' = \frac{2.314 \sin E'}{n} \quad (11)$$

$$F' = E' + J'' \quad (12)$$

$$C' = E' - K'' \quad (13)$$

$$F = E + J'' \quad (14)$$

$$C = E - K'' \quad (15)$$

$$s = \frac{d}{n} = \frac{D}{N} \quad (16)$$

$$d'' = s \cos E' \quad (17)$$

$$D'' = s \cos E \quad (18)$$

$$d_e = \frac{n}{p} \quad (19)$$

$$d' = d + 2d'' \quad (20)$$

or for greater accuracy:

$$d' = d + \frac{2d''d_e}{d}$$

$$D' = D + 2D'' \quad (21)$$

or for greater accuracy:

$$D' = D + \frac{2D''D_e}{D}$$

Derivation of Foregoing Formulas

The similarity of the formulas for type B skew bevel gears and for ordinary bevel gears is so marked that little explanation of their derivation is necessary, other than that of the equivalent pitch diameter formulas.

The equivalent pitch diameters of ordinary bevel gears which would give the same speed ratio as gears with oblique teeth are not quite so evident from Fig. 2 as the equivalent pitch diameter of type A skew bevel gears is made from Fig. 1; but it is quite evident that the actual pitch diameters of the gears with oblique teeth must be greater than those of a similar combination of gears with straight (radial) teeth. In the case of type A skew bevel gears it was quite apparent that the pitch diameter D of the gear depended upon the offset X of the pinion shaft; so it must follow that for skew bevel gears of type B, where the increase in diameter is reduced by making both the pinion and gear teeth equally oblique, the pitch diameter is also dependent upon the offset X of the pinion shaft, *i. e.*, that proportion of the total offset which governs the obliquity of the teeth. The formulas for the actual pitch diameters must then be similar to that for the actual pitch diameter of the type A skew bevel gear, the proportional offset governing the obliquity of the teeth, and its corresponding angle of offset simply taking the place of the total offset and its angle of offset used in the formula for type A gears.

The circular pitch of both gear and pinion are necessarily the same in type B gears, but are somewhat greater than the normal pitch which conforms to the circular pitch of similar gears with radial instead of oblique teeth. The diameter increments of both gear and pinion are actually somewhat less than they would be if the teeth were radial, so in the formulas for outside diameters (the ones for greater accuracy) the same modification is employed as for type A gears.

Example in Design of Skew Bevel Gears—Type B

Example.—Required: A pair of skew bevel gears of 5 diametral pitch, with 60 teeth in gear and 15 teeth in pinion; the pinion shaft offset to be 5 inches. The diametral pitch corresponds to the normal pitch of the gears.

Radius V of circle of apexes for pinion:

$$V = \frac{5}{4+1} = 1 \text{ inch.} \qquad (1)$$

Radius W of circle of apexes for gear:

$$W = 4 \times 1 = 4 \text{ inches} \qquad (2)$$

Equivalent pitch diameter D_e of gear:

$$D_e = \frac{60}{5} = 12 \text{ inches} \qquad (3)$$

Angle of offset y for pinion:

$$\tan y = \frac{2 \times 1}{12} = 0.1667 \qquad (4)$$

$$y = 9 \text{ degrees, } 28 \text{ minutes}$$

Pitch diameter D of gear:

$$D = \frac{2 \times 1.0}{0.16447} = 12.16 \text{ inches} \qquad (5)$$

Pitch diameter d of pinion:

$$d = \frac{12.16 \times 15}{60} = 3.04 \text{ inches} \qquad (6)$$

Circular pitch P'':

$$P'' = \frac{3.1416 \times 3.04}{15} = 0.6367 \text{ inch} \qquad (7)$$

Center angle E' of pinion:

$$\tan E' = \frac{3.04}{12.16} = 0.2500 \qquad (8)$$

$$E' = 14 \text{ degrees, } 2 \text{ minutes}$$

Center angle E of gear:

$$E = 90 - 14 \text{ degrees, } 2 \text{ minutes} = 75 \text{ degrees, } 58 \text{ minutes} \qquad (9)$$

Angle increment J'':

$$\tan J'' = \frac{2 \times 0.2425}{15} = 0.03233 \qquad (10)$$

$$J'' = 1 \text{ degree, } 51 \text{ minutes}$$

Angle decrement K'':

$$\tan K'' = \frac{2.314 \times 0.2425}{15} = 0.03741 \qquad (11)$$

$$K'' = 2 \text{ degrees, } 9 \text{ minutes}$$

Face angle F' of pinion:

$$F' = 14 \text{ deg., } 2 \text{ min.} + 1 \text{ deg., } 51 \text{ min.} = 15 \text{ deg., } 53 \text{ min.} \qquad (12)$$

Cutting angle C' of pinion:

$$C' = 14 \text{ deg., } 2 \text{ min.} - 2 \text{ deg., } 9 \text{ min.} = 11 \text{ deg., } 53 \text{ min.} \qquad (13)$$

Face angle F of gear:

$$F = 75 \text{ deg., } 58 \text{ min.} + 1 \text{ deg., } 51 \text{ min.} = 77 \text{ deg., } 49 \text{ min.} \qquad (14)$$

Cutting angle C of gear:

$$C = 75 \text{ deg., } 58 \text{ min.} - 2 \text{ deg., } 9 \text{ min.} = 73 \text{ deg., } 49 \text{ min.} \qquad (15)$$

Addendums:

$$s = \frac{3.04}{15} = 0.2027 \text{ inch} \qquad (16)$$

Diameter increment d'' of pinion:

$$d'' = 0.2027 \times 0.97015 = 0.1967 \text{ inch} \qquad (17)$$

Diameter increment D'' of gear:

$$D'' = 0.2027 \times 0.24249 = 0.0492 \text{ inch} \qquad (18)$$

Equivalent pitch diameter d_e of pinion:

$$d_e = \frac{15}{5} = 3 \text{ inches} \qquad (19)$$

Outside diameter d' of pinion:

$$d' = 3.04 + (2 \times 0.1967) = 3.433 \text{ inches} \qquad (20)$$

or for greater accuracy:

$$d' = 3.04 + \frac{2 \times 0.1967 \times 3}{3.04} = 3.428 \text{ inches}$$

Outside diameter D' of gear:

$$D' = 12.16 + (2 \times 0.0492) = 12.258 \text{ inches} \qquad (21)$$

or for greater accuracy:

$$D' = 12.16 + \frac{2 \times 0.0492 \times 12}{12.16} = 12.257 \text{ inches}$$

Machining Skew Bevel Gears—Type B

Skew bevel gears, in which the teeth of both pinion and gear are of equal obliquity, should be completely cut on one machine with its spindle offset from the plane of the cutting tool a distance equal to the radius of the circle of apexes for the gear being cut, the facing angle (shop angle) cut being taken with the machine so adjusted, as well as all the operations of cutting the teeth. The angularity of the facing angle thus cut is the true angularity of the face surface—also of the pitch surface, if teeth of equal depth are cut—so that the true face angle is the requisite amount greater than the angularity of the face surface. The slight inaccuracy of assuming the radial line angles of the gears to be the same as those on lines normal to the circular pitch circumferences is thus automatically corrected. However, should it be deemed advisable to perform the facing cut on a lathe, as in the case of type A skew bevel gears, the face angles ascertained by Formulas (12) and (14) may be safely used, unless the offset of the pinion shaft should be very pronounced and the speed ratio of the gears also large, for the slight error arising would tend only very slightly to throw the teeth out of perfect mesh toward the inner edge of the gears, where but a small proportion of the power is really transmitted. The operations following the facing of the gear blanks are exactly similar to those employed when finishing type A skew bevels and demand the same care.

Sliding and Tooth Proportions of Skew Bevel Gears

The obliquity of type B skew bevel gears produces the sliding action referred to in the discussion of type A skew bevel gears—though to a lesser degree—and this results in both a slight drawback and a decided advantage. The drawback is due to failure of the teeth to clear properly if the common 14½-degree involute tooth is used, but this is overcome by employing a more obtuse angled tooth. In the ordinary installation, a 20-degree involute tooth clears satisfactorily, and this is the type of tooth usually cut. In extreme cases, where the offset of the pinion shaft is particularly pronounced, an even greater tooth angle might be employed to advantage, but it is very doubtful whether such need would arise in any but extremely freak gear combinations. The advantage possessed by skew bevel gears is their smooth and powerful action, as compared with that of common bevel gears. The sliding action of the teeth reduces the impact shock, which is the chief disadvantage of spur gearing, while the rolling action of the teeth makes the gears more powerful and reliable than spiral gears which depend entirely upon sliding action for their operation. Skew bevel gears are really excellent power transmitters and deserve greater popularity, particularly as they are in reality neither difficult to lay out nor hard to machine.

* * *

BILL FOR LEGALIZING THE CENTIGRADE SCALE

A committee of the National Academy of Sciences, consisting of Messrs. Abbot, Stratton and Marvin (the heads, respectively, of the Smithsonian Astrophysical Observatory, the Bureau of Standards and the Weather Bureau), appointed to consider the bill before congress discontinuing the use of the Fahrenheit temperature scale in government publications, reported at the last annual meeting of the academy in favor of the bill, but recommended two amendments. One of the latter provides that "when in the publication of tables containing several meteorological and climatic elements the use of data in centigrade temperatures leads to manifest incongruities, the chief of the weather bureau is directed to publish related data in such units as are necessary to make the tables homogeneous and to secure international uniformity as far as practicable." The other amendment would authorize the use of the absolute centigrade scale.

* * *

Steel cast flywheels running at peripheral speeds in excess of 4000 feet per minute should be double annealed; heavy steel gears should be annealed once, but steel frames and similar steel casting machine members seldom require annealing.

MACHINERY POUND PRICES

BY A. B. HAZZARD*

Builders of standard machinery are usually averse to having their products referred to by a pound price. Manufacturers who have designed, built and refined high-grade machinery have always been greatly irritated by having a customer who has received a quotation, together with weights, specifications, etc., refer to the matter by quoting a price by the pound. This in an injustice to the manufacturer and invariably shows the inability of the buyer and his lack of mechanical knowledge.

In the first place, the average purchasing agent does not buy large machinery often enough to keep in touch with the progress of improvements. It is obviously unfair to make comparisons between machine tools of the same type unless the various types of machines possess the same degree of refinement and are provided with the same improvements. The design and relative efficiency of many types of machines are so varied that they cannot be compared with any degree of justice by referring to one or the other by a pound price. A universal milling machine having a single-pulley drive and quick-feed change-gears cannot be compared by a pound price with a Lincoln type milling machine having a cone head and belt feed of the same working dimensions, regardless of the number that are manufactured. The latter would cost probably half the price of the former, and yet both would take the same size milling cutters and would perform the same operations in many cases. Yet the adaptability of the universal machine to conditions which could not be met on the Lincoln type milling machine would make any comparison by a pound price between the two types of machines an unfair one. Taking another example, a 6-foot swing lathe will cost over twice as much as a 6-foot vertical boring mill, and each will have its respective advantages over the other with certain classes of work.

MACHINERY POUND PRICES

Machine Tools	Price per Pound	
	Minimum	Maximum
Boring mills, vertical (large)	$0.12	$0.16
Drilling machines, upright (plain)	0.20	0.25
Drilling machines, radial (plain, cone pulley drive)	0.14	0.18
Drilling machines, radial (quick-change feeds, motor drive)	0.18	0.26
Lathes, engine—standard type (cone pulley drive)	0.12	0.18
Lathes, engine—patent head (quick-change gears)	0.14	0.24
Lathes, gap	0.15	0.25
Lathes, turret chucking (18 to 24 inches)	0.15	0.28
Milling machines, plain	0.18	0.25
Milling machines, universal (quick-change gears)	0.30	0.55
Planers, regular	0.10	0.18
General		
Aeroplanes	0.60	2.00
Aeroplane motors—six-cylinder	1.50	4.75
Aeroplane motors—eight-cylinder	2.50	5.50
Air compressors	0.10	0.25
Automobile motors—four-cylinder	0.32	0.60
Automobile motors—six-cylinder	0.38	0.70
Automobile radiators	0.42	0.80
Barbed wire machines	0.17	0.24
Locomotives	0.07	0.12
Steam engines, Corliss type	0.08	0.14
Steam engines, vertical marine type	0.12	0.18

A number of illustrations can be given along these lines, such as comparing a standard engine lathe with the average toolmaker's lathe designed for precision work. The standard lathe will do many pieces of good tool work, especially when handled by an experienced operator, and while it cannot be handled as quickly as the quick-change gear type of machine, the class of work produced compares very favorably with that of the higher-priced machine. The same principles are applicable to parts for automobiles. The frame must be made to suit the design, and although a plain straight frame is cheaper to make than one with an offset at the rear or one tapered front and back, the weight of the two frames would be about the same. A cellular type radiator is bought for its efficiency, while the fin and tube type is much cheaper to make, and yet the weights of the two would not differ greatly. So with an engine, transmission or rear axle for an automobile, the degree of refinement to which these parts are subjected in the machining and the improvements in design would all have an effect on the pound price, and yet the weight of a cheap axle or other part and the weight of one of the more improved types might not be very different.

The factory engineers who are constantly working out the different mechanical propositions connected with the machining of the parts in a motor car, and who have to do with jigs, fixtures and other devices for the production of these parts, are among the few people who can even talk about pound prices with any degree of accuracy. On this class of work it is very difficult to make an estimate of a price per pound, because of the variations in the types of fixtures and their requirements for accuracy. A fixture might be large and heavy and weigh several hundred pounds, yet it might have very little accurate work in its manufacture; while, on the other hand, a small fixture of little weight might have many refinements in its design and might require to be very carefully made, so that the price per pound would be extremely high. A Corliss engine of a horsepower corresponding to that of a triple expansion vertical marine engine might perform the same duty, yet could not be compared to the other by a price per pound. Machined castings for structural work, sole plates, furnace parts, etc., are very rough work, and have therefore been sold largely on a pound price basis.

When new machinery is to be purchased, the factory engineer must carefully consider the class of work and the amount to be done, as well as the accuracy, and select a machine tool of suitable type to perform the required work. The designing engineer who builds machinery, tools or engines generally estimates the weight and the labor separately and adds the cost of the two together, finally converting the whole into a pound price for labor and material. This is done for his own information, but when completed and the cost is turned over to the works manager and sales department, the pound price is entirely lost. When contracts are to be let for large special machinery, the large shops with a heavy overhead expense often have an advantage over the smaller factories, because their equipment is more suited to the handling of this heavy work. When light machines are to be built, however, the small shops can many times build them cheaper because of their lighter overhead expense.

It should be remembered that although pig iron costs from $16 to $20 per ton and steel from $30 to $60 per ton, this does not mean that any kind of machinery can be made for any fixed price per pound. There are so many factors that enter into the manufacturing of any mechanical device that there is no good reason why a price per pound should be considered in purchasing. It is of interest, however, to note the range in prices for the various mechanical devices, and to permit of making these comparisons the accompanying table has been prepared.

* Address: 257 Westfield Ave., Elizabeth, N. J.

* * *

The diamond tool is the most efficient means for truing the face of grinding wheels for precision work so far discovered. The reasons are: (1) Diamonds or bortz are harder than the wheel to be trued. (2) They are obtainable in sufficient quantities to meet the demand. (3) They provide a means of making the wheel a true cylinder and at the same time provide any kind of wheel service desired. (4) They lend themselves to a reasonably easy setting and are conveniently applied to the work. (5) The waste of the wheel is negligible.—*Grits and Grinds.*

TESTING SPECIAL SHELL-BORING LATHES

BY L. C. MORROW*

The operation of testing various machine tools for accuracy and the methods used in aligning the parts are always of interest. The special shell-boring lathe illustrated in Fig. 1 is designed to bore 12-inch high-explosive shells having an open base and screwed adapter. The fundamental features of the design are as follows: flat bed, two-step cone, double back-gears, bell chuck supported by steadyrest, stationary carriage while boring, power traverse to carriage for running back to permit removal of shell after boring, movable boring-bar with feed, and link former for nose. This machine is made by the Giddings & Lewis Mfg. Co., Fond du Lac, Wis. Reference to Fig. 1 will show the general characteristics of the lathe, and a shell *A* can be noted in the chuck ready for boring.

Method of Aligning Spindle

Fig. 2 shows the method of aligning the spindle when erecting the lathe. The disks *A* are machined very accurately, the faces of both disks and hubs being machined while on the arbor. They have a diameter equal to one-half the length of the base of the headstock. One disk fits over the spindle nose and is pulled up against the shoulder of the spindle by a long bolt (not shown) running through the spindle. The other disk is attached to a bar which is supported on two brackets *B*, which are set on the bed. The pins *D* bear against the vertical surface on the bed, against which the thrust of the carriage is taken and on which it slides. The disks are brought together and thickness gages tried between them when testing. In this way it is easy to determine in which direction the spindle is out of alignment and just how much it may be out. The thickness of the gages which will enter between the disks should be multiplied by two, in order to find the error in alignment of the headstock.

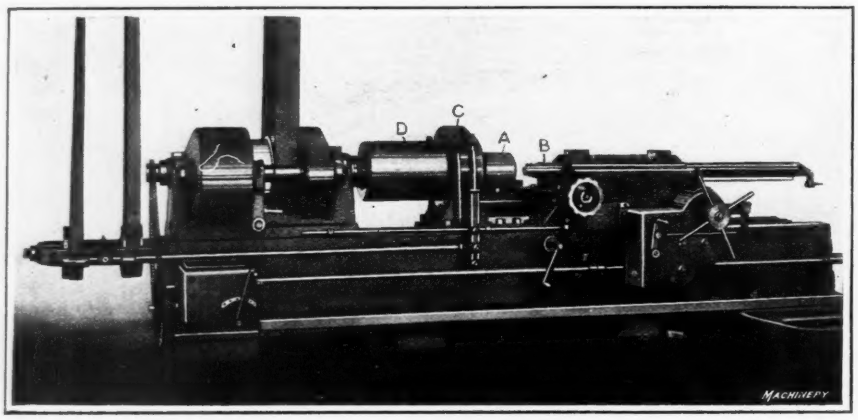


Fig. 1. Special 12-inch Shell-boring Lathe

Method of Aligning Boring-bar

Referring once more to Fig. 1, it will be seen that the alignment of the boring-bar *B* is quite important in order that accurate work may be done by the machine. In aligning the boring-bar an indicator is attached to a stand of suitable form (not shown) which rests on the bed and has a bearing against the vertical grinding surface as in the case of the support *B* in Fig. 2.

* Address: Lockland, Ohio.

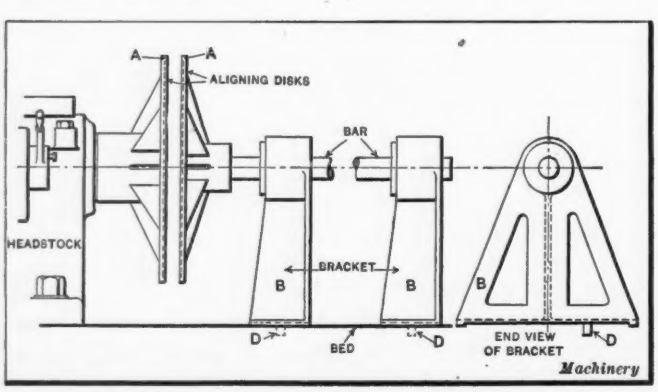


Fig. 2. Spindle Aligning Tools used in testing Shell-boring Lathe

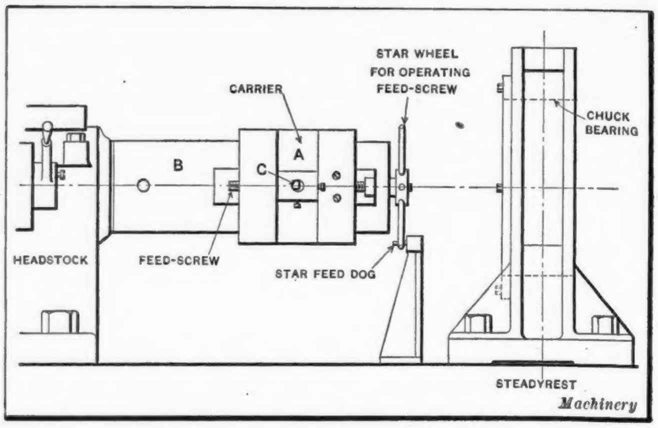


Fig. 3. Combination Boring and Turning Tool

Boring Steadyrest

In order to insure accuracy, the steadyrest shown at *C* in Fig. 1 must be bored in position, and, furthermore, each steadyrest must be bored in position on its own lathe. This work is accomplished by a special cutter-head or boring head shown in Fig. 3. This cutter-head is provided with a tool *C*, which is adjustably mounted on the carrier *A*. This carrier, in turn, is a sliding fit along the cylinder *B*, which is mounted on the spindle nose. The feeding mechanism is operated on the star wheel principle, as indicated in the illustration. The steadyrest is shown out of its true position so that the details of the boring head may be more clearly apparent. The steadyrest is supplied with a bushing that may be renewed at any time when worn.

Turning Chuck Steadyrest Bearing Surface

That part of the chuck which runs in the steadyrest must also be turned in position, as any error made in fitting the thread of the chuck to the nose of the spindle would be considerably exaggerated at the outer end of the chuck. It is important, therefore, that the turning should be done on the lathe on which it is to be used, so that accuracy will be assured. The same tool which is used for boring out the steadyrest is employed in turning the bearing mentioned, the tool being clamped to the bed of the machine for the purpose and

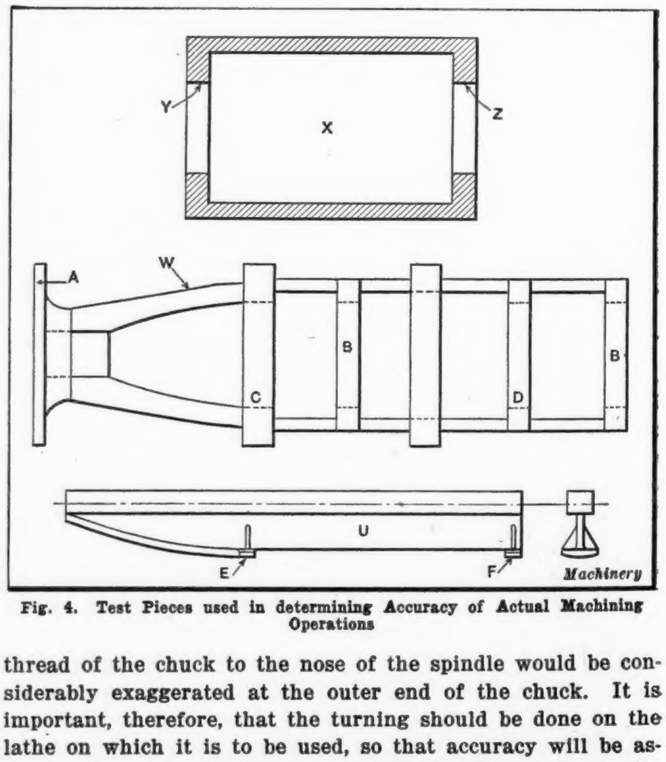


Fig. 4. Test Pieces used in determining Accuracy of Actual Machining Operations

the star feed dog attached to the chuck to provide the necessary feed movement.

Boring and Testing Chuck

After the chuck and steadyrest have been applied to the machine, it is necessary to bore the inside of the chuck for a distance of about 6 inches from the rear end, this bored portion later receiving a bushing machined to the proper shape to center and support the nose end of the shell. In order to know that the boring-bar is properly set to bore this hole straight, a test cylinder *X* shown in Fig. 4 is first bored. The cylinder collars *Y* and *Z* must show that the bore is parallel or at least that it will not be small on the front end. Naturally, the bore in the chuck is tested for accuracy during the machining process.

Final Test

The final test of the machine is to bore a shell in order to see that the alignment is within the permissible limits of error and that the curve of the nose on the shell is properly formed. For this purpose a cast-iron test shell *W* is used, this shell having a flange *A* which fits the bored portion of the chuck, thus giving practically the same support which the forged shell receives. The diameters of the collars *B* are measured in order to determine that the straight bore is parallel and cylindrical. The curve on the nose of the shell is measured by an accurately made templet shown at *U* in Fig. 4, this templet having two feet *E* and *F* which rest at the points *C* and *D* in the shell. The amount of error in the curve is determined by thickness gages. By using the test shell with segments cored out as shown, yet having the heavy collars as braces, a strong piece is obtained to which the templet may be applied at any time without sawing out a section. This piece can be quickly bored and may also be rebored a great many times, so that its economy is apparent.

* * *

A. S. C. E. TO SHARE ENGINEERING SOCIETIES BUILDING

The American Society of Civil Engineers has voted to accept the offer of the United Engineering Society to become an equal partner with the three founder societies, the American Institute of Electrical Engineers, the American Institute of Mining Engineers and the American Society of Mechanical Engineers, in ownership, occupancy and administration of the Engineering Societies Building and all other activities which the societies may jointly undertake. Thus is the hope of Andrew Carnegie, the donor of the building, fully realized—that the building should become the home and headquarters of the engineering profession in America.

Three stories will be added to the top of the Engineering Societies Building, and planned for the extension of the library and for the use of the A. S. C. E. The cost will not exceed $250,000. The arrangement with the A. S. C. E. is to permit it to reimburse the United Engineering Society for the cost of the enlarged building, this sum being substantially the same as the amount paid by the founder societies originally for their participation in the enterprise. Thus all four societies enter upon the same basis and share equally in all respects.

Ten years ago, when the Engineering Societies Building was constructed, the A. S. C. E. was invited by Mr. Carnegie to be a founder society in the building. The society decided at that time not to accept the offer, however, but to continue to occupy its own house on 57th St., which it had built about ten years earlier.

At the time of the undertaking of the founder societies, there was doubt as to the success, financially and technically, of the scheme for associating several societies in one building. The construction and dedication of the building were looked upon by some as the first steps of a severe trial of the management of the societies. Many questioned whether the three participating societies in Mr. Carnegie's gift would live together in harmony and be able to carry out the plans suggested. Some questioned the feasibility also of uniting the three independent libraries of the societies into one joint library, useful to members of any of the three societies for research and consultation. Some did not see how the housing of the three national societies and several minor associations under one roof would bring about the desirable closer cooperation of the various members of the profession without at the same time causing some of the organizations to be "swallowed up" by some of the others.

The experience of ten years has shown that all these criticisms of the project have become groundless. The financial stability of the Engineering Societies Building is now fully established. The building represents an investment of practically $2,000,000. The societies own it free of all encumbrance, and have in addition over $70,000 in a separate reserve fund to provide for depreciation and amortization. Each society has itself prospered. The American Society of Civil Engineers will now pay about $225,000 for the addition to the building, and each of the four founder societies will then hold an equity in the property of over half a million dollars.

Eighteen societies, including the three original founder societies, now make the building their headquarters. Each is under its own management absolutely, and all live in independence and harmony. Frequent conferences are held in matters pertaining to the welfare of the engineering profession as a whole. With the civil engineers, the total membership represented in the building will be 52,677, as shown by the following figures of present membership of the resident societies:

American Society of Civil Engineers	8022
American Institute of Electrical Engineers	8308
American Institute of Mining Engineers	5597
The American Society of Mechanical Engineers	7149
Aeronautical Society of America	200
American Society of Heating and Ventilating Engineers	705
American Gas Institute	1530
Association of Edison Illuminating Companies	73
American Institute of Aeronautical Engineers	121
Empire Gas and Electric Association	115
Illuminating Engineering Society	1350
Municipal Engineers of the City of New York	600
National Electric Light Association	14,000
National Association of Engine and Boat Manufacturers	175
New York Electrical Society	705
Society for Electrical Development	1128
Society of Naval Architects and Marine Engineers	900
Society of Automobile Engineers	1975
U. S. Naval Consulting Board	24

The joint library of the United Engineering Society has in ten years become the greatest and potentially the most useful engineering library in the world. Accessions are now being made at the rate of three thousand annually, and the collection amounted, at the time of the last annual report of the library board, to over 62,500 volumes. At that date, 1020 publications were being received periodically, and current numbers of over 1000 periodicals were on file upon the shelves in the reading room so as to be readily accessible. The consolidation of the valuable A. S. C. E. library with the others will enlarge the scope of the library so that it will become of use to any member of the entire engineering profession.—*Journal A. S. M. E.*

* * *

HARDENING IN ELECTRIC FURNACES

The latest electric furnaces cost about the same to operate as gas furnaces when the current is 3½ cents per kilowatt and the gas is 80 cents per thousand cubic feet, the gas having about 600 B.T.U. per cubic foot. One concern having electric furnaces using current at 1¾ cents per kilowatt gets its work hardened at a cost of about one-fourth cent a pound. But even if the cost were higher than with gas there is the great advantage of perfect control. An autographic record of the rise in temperature clearly indicates the critical point in the curve, and when the temperature has risen a few degrees above as shown by the recorder the charge is removed. Thus the hardener has an infallible guide, provided the pyrometers are checked daily and each heat is recorded. Inspection is checked against these records and each lot of steel is tested before fixing the temperature for quenching. By such exact methods do modern plants insure that work shall be uniform in hardness.

COMMERCIALIZING CARTRIDGE CASE MANUFACTURE*

DEVELOPMENT OF DIES, TOOLS AND METHODS FOR THIS WORK BY THE WORCESTER PRESSED STEEL CO.

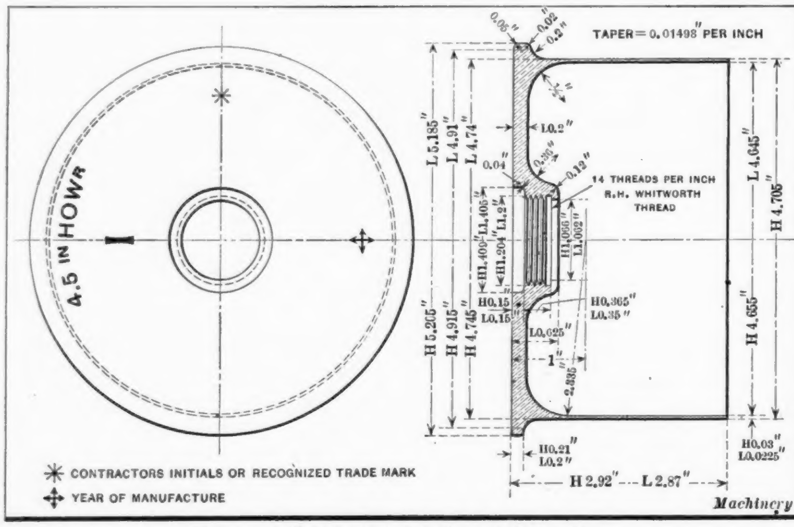


Fig. 1. British 4.5-inch Howitzer Cartridge Case

THE first orders received in this country for munitions were taken by many concerns that did not appreciate the difficulties attending the production of this class of work. Many manufacturers without previous experience in the production of munitions took orders which proved very unsatisfactory, while others, after considerable delay and expense, were finally able to make deliveries. The number of concerns that met with the anticipated success were few, and, as might be expected, were those that possessed special ability in similar classes of work. One of the successful concerns is the Worcester Pressed Steel Co., Worcester, Mass., which for years has made a specialty of sheet metal stamping products. Orders placed with this firm for 1,300,000 4.5-inch British howitzer cartridge cases have been successfully filled in two weeks less than the time specified. This is one of the few contracts for munitions let in this country which has been completed ahead of the date set, by far the greater number being long over-due.

The solution of the problems of production was not by any means simple, and at least one month's time was taken to analyze the proposition before any work was started. When the plan of procedure was decided upon, all the dies, tools and fixtures were ready for operation inside of six weeks, and in two months' time shipments for testing were started. The original lay-out was planned to handle 4000 cartridge cases in twenty-four hours, and this was done without putting up any additional buildings, and with the purchase of only a few special machines, such as heading presses, drill presses and turret lathes. Inside of six months 10,000 cartridge cases were being turned out in twenty-four hours with the equipment that was laid out for handling 4000. The only reason why such an increase was made was the systematic way in which the work was handled, as will be explained later. Another remarkable thing is that not one cartridge case has been rejected by the government inspectors at the proving grounds for failing on firing test, and in this plant, before the order was finally completed, the percentage of scrap was 2½, and it never exceeded 6. Of course, there are many reasons why this proposition was so successfully worked out, and in the following a few of these will be covered, especially those pertaining to the design and construction of the tools and the methods of systematically routing the work.

Requirements that had to be Met

The following are some of the principal requirements and specifications to which the cartridge case must be made: (1) It must be made to certain dimensions within specified limits. (2) It must be of a certain hardness both on the head and on the walls. (3) It must have a certain ductility. (4) It

* For information on cartridge case manufacture previously published in MACHINERY, see "High-explosive Shell Cartridge Cases," December, 1915; "Making Cartridge Cases," April, 1915; "Loading and Clipping Cartridges," May, 1914, and articles there referred to.

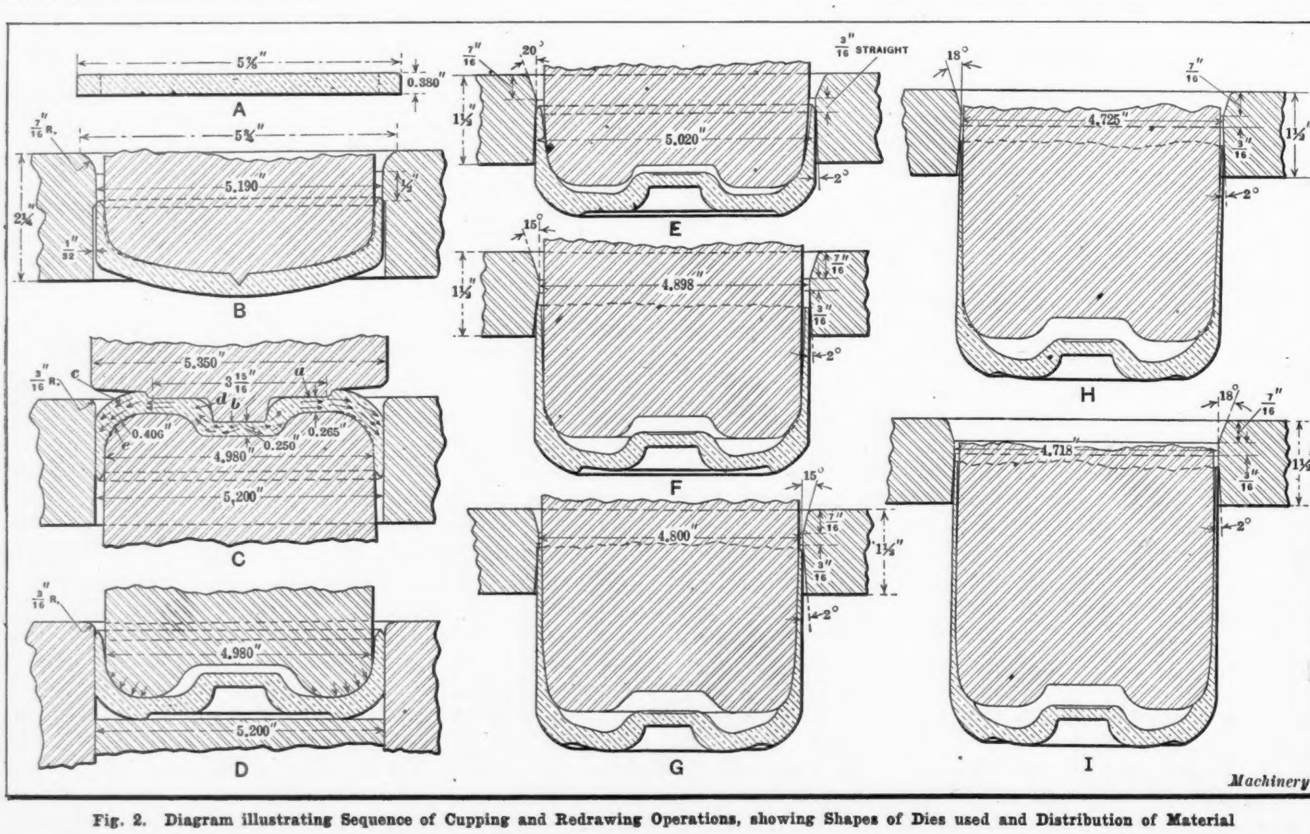


Fig. 2. Diagram illustrating Sequence of Cupping and Redrawing Operations, showing Shapes of Dies used and Distribution of Material

must be capable of resisting an excess charge and used for firing three shots; that is, it must be capable of withstanding three firings without being destroyed. (5) It must be free from all surface imperfections, such as cracks, flaws, etc. Another requirement demanded is that the case during its manufacture must receive a certain number of annealings. In other words, the number of annealings must not be less than five. To produce a cartridge case under these conditions is not as easy as it might seem, and satisfactory results are possible only by careful consideration of the work that must be accomplished and the requirements that must be obtained, and making suitable provision for meeting them.

Method of Analyzing Operations

When the Worcester Pressed Steel Co. took the contract for the manufacture of this cartridge case, it proceeded to analyze the various operations by the same method as would be followed on any regular contract work. The drawing of the cartridge case was carefully gone over and the method of procedure outlined. The size of the blank recognized as being standard for this particular case was 6 inches diameter, 0.380 inch thick. After several experiments, it was found that a 6-inch blank left too much scrap, and a blank 5⅞ inches diameter was decided upon. Another question that had to be settled was the size and shape of the cup. Upon referring to Fig. 1, which shows a drawing of the completed case, it will be seen that practically no material is to be taken from the head of the case; in fact, additional material has to be collected to form the head, especially at the corners. This means that a comparatively thick blank has to be drawn up into a very shallow cup and then the metal in the walls stretched to the required length without taking any more material from the corners. To meet this condition it was necessary that in no redrawing operation should the punch bear on the bottom of the cup, but should hit the inside of the cup so that the metal was confined at the point where the contact was made in such a way that no material was drawn from the base to form the extended walls. In other words, the metal existing in the walls was to be stretched until the desired length was attained. Another difficulty was the handling of such a shallow cup of large diameter. Great trouble was experienced in preventing the blank from tipping to one side. This was finally solved by the use of a center in the cupping punch which, as shown in Fig. 2, centers the blank accurately when it is being drawn through the die for the first operation. Of course this die, not having a blank holder, was provided with a circular guide around its top face in which the blank was accurately centered. Six blanks were made before the exact shape of the dies and punches was obtained, and considering the difficulties encountered, this result is remarkable. One of the greatest difficulties experienced was in getting the metal to flow in the right direction.

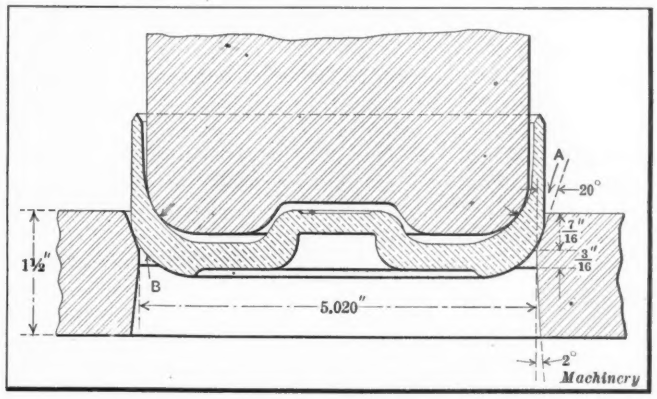


Fig. 3. Diagram illustrating Action that takes place when Cup is forced through Redrawing Die—this illustrates Relation of Cup to Die before Second Redrawing Operation

Controlling Flow of Metal

Starting with the operations in the order in which they are accomplished, the following are a few of the difficulties that were encountered. In the first place, it was found that, owing to the shallowness of the cup required, great difficulty was experienced in keeping the blank from sliding and tipping during the cupping operation. To overcome this difficulty, the first cupping punch, as previously mentioned, was provided with a teat as shown at *B* in Fig. 2, which produced a corresponding hole in the blank and thus centered it before the actual cupping took place. It was also found that the metal drew much more evenly when the blank was located in the cupping die with the rounded edge up.

After several cups had been made it was found that the thickness of the blank was slightly less than that actually required to produce the case most easily. In order to get sufficient material in the base, the cupping punch was "domed" and made considerably larger than the difference between the diameter of the die minus twice the thickness of the metal. (This is clearly shown at *B* in Fig. 2.) In other words, the thickness of the walls of the cup was reduced to about one-half the original thickness of the blank. As the cup was so short and the finished wall at the top edge comparatively thin, sufficient metal could be gathered in this way for redrawing in order to produce a case of the required shape. If more metal had been used, considerable waste of stock would have been involved.

Indenting and Flattening

In ordinary redrawing operations it is not usually necessary to prevent a slight flow of metal from the base of the cup. In this case, however, such a result had to be avoided, and, in fact, additional metal had to be forced toward the lower edges of the cup in order to furnish sufficient material to produce the thickness and shape of head required.

In order to prevent the metal from flowing from the bottom of the cup, the indenting operation was made to follow the first cupping operation. This, as shown at *C* in Fig. 2, was accomplished with the cup inverted and the indenting punch

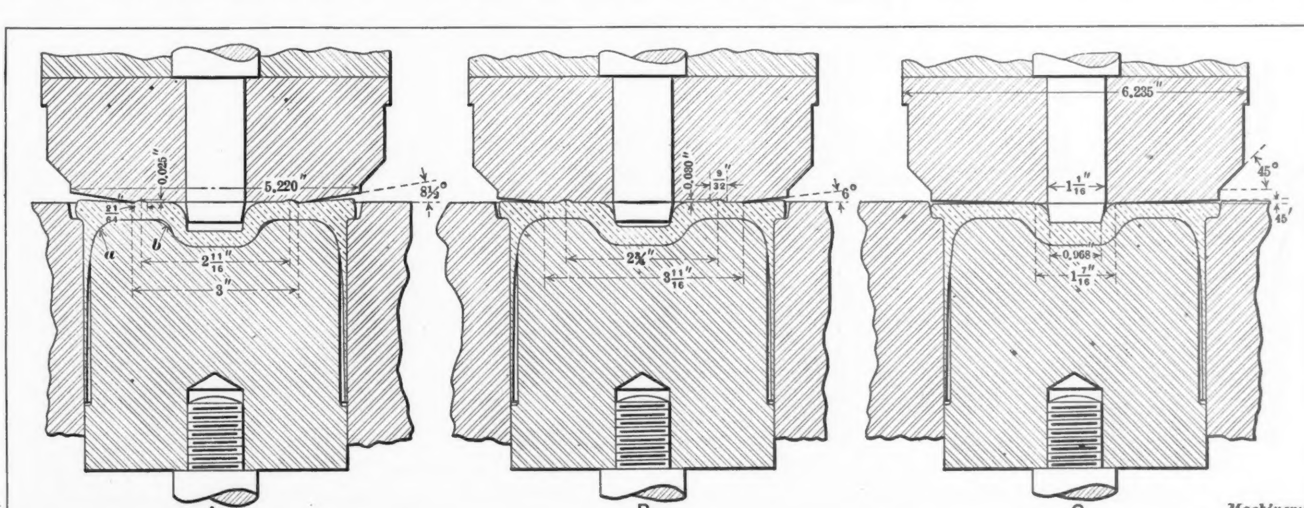


Fig. 4. Diagram illustrating Shape of Heading Punches and Flow of Metal in Head under Pressure

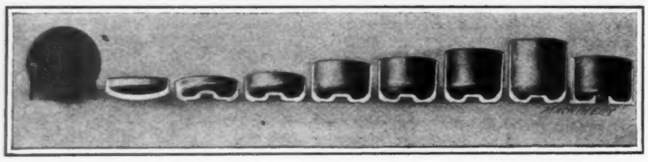


Fig. 5. Cupping, Redrawing and Heading Operations on Cartridge Case

Fig. 6. Shape of Case after cupping and indenting

so made that it "squirted" the material to the corner, as shown by the arrows, packing it up considerably.

It will be noticed in this case that the indenting punch reduced the thickness of the metal at point *a* from 0.380 inch to 0.265 inch; and at point *b* from 0.380 to 0.250 inch. This resulted in the displacement of considerable material which was distributed to points *c* and *d*. A reaction took place at the point *e*, so that as soon as the cup was removed from the die the material at the point mentioned sprung out about 1/32 inch.

Difficulty was also experienced in getting a sufficient amount of material around the primer pocket, and in getting the proper location of the indent for heading. In making the lower indenting punch, the recess to form the indent was made with a radius 1/32 inch greater than that called for on the drawing. This allowed this amount of material to be spread out in heading so as to harden the head and give the desired scleroscope reading. The radius on the inside corner was also increased from 1/2 to 9/16 inch, which provided material that could be spread out so as to fill up the corners in the final heading operation.

The amount of work done at this operation, however, was not sufficient to distribute the required amount of material to point *c*, and following the indenting operation a flattening operation was accomplished. This is shown at *D* in Fig. 2, and was handled with the cup in the same manner as that in which it would be redrawn. Instead of forcing the cup, however, through a die, which in this case was simply a retaining ring, it was butted down against a flat, hardened punch. The upper flattening punch was so made that the greatest pressure exerted was directly in the corners, resulting in throwing the material down 1/8 inch further; that is, the point where the radius joins the plain exterior surface of the cup was thrown down to this amount. These two operations were found to give the required amount of material in the corners, but in the subsequent operations, of course, care was taken not to disturb it. Referring to *D* in Fig. 2, it will be noticed that the flattening punch bears only in the corner and is relieved at all other points.

Redrawing Operations

An annealing operation takes place between the indenting and flattening operations, as will be described in detail later. The cup is taken directly from the flattening to the first redrawing operation. In the first redrawing operation, shown at *E* in Fig. 2, it will be noticed that the walls of the cup are extended very little and it is reduced 3.27 per cent (see Table II), which is considerably less than usual in ordinary redrawing operations. Generally the reduction varies all the way from 8 to 20 per cent, sometimes even more, depending on the thickness and character of the material. In this case it will be noticed that the reduction is comparatively slight. The reason for this is that an endeavor is made to coax the material to flow upward without disturbing the material in the base, and especially at the corners. Reference to Fig. 3 will show that the punch, in starting to draw the cup, bears only in the corners, the pressure being greatest at a point about 1/8 inch higher than where the cup contacts with the drawing angle in the die. In this way only the material in the walls of the cup is extended, the thickness of the metal in the bottom and at the corners being unchanged.

Considerable trouble was experienced in getting the cup to draw correctly in this operation. In the first die a round corner was tried similar to that used for cupping, but it was found that the metal shot under the punch and did not leave sufficient material to extend the walls to the required length. Next an entrance angle of 15 degrees was tried, but this gave results that were unsatisfactory. Finally the angle *A*, Fig. 3,

TABLE I. OPERATIONS ON BRITISH 4.5-INCH HOWITZER CARTRIDGE CASE

Operation No.	Operation	Machine Used	Lubricant	Furnace Used	Temperature, Degrees F.	Time in Minutes	Bath	No. of Operators	No. of Helpers	Production per Hour
1	Cup	Bliss 12" stroke	Lube-a-Tube	....	....	..	....	1	2	525
2	Indent	1000 ton Toledo knuckle press	Lube-a-Tube	....	....	..	....	1	1	500
3	Anneal, pickle and wash	......	......	Rockwell	1250	40	Water cooled	1	3	600
4	Flatten	Toledo 8" stroke	......	....	....	..	....	1	1	1100
5	First redraw	Toledo 8" stroke	Lube-a-Tube	....	....	..	....	1	2	900
6	Wash	Washing tank	......	....	....	..	....	1	1	700
7	Anneal, pickle and wash	....	......	Rockwell	1250	40	Water cooled	1	3	500
8	Second redraw	Bliss 12" stroke	Lube-a-Tube	....	....	..	....	1	2	550
9	Wash	Washing tank	......	....	....	..	....	1	1	540
10	Anneal, pickle and wash	......	......	Rockwell	1250	40	Water cooled	1	3	500
11	Third redraw	Bliss 12" stroke	......	....	....	..	....	1	2	550
12	Wash	Washing tank	......	....	....	..	....	1	1	540
13	Anneal, pickle and wash	......	......	Rockwell	1250	40	Water cooled	1	3	500
14	Fourth redraw	Bliss 12" stroke	Lube-a-Tube	....	....	..	....	1	2	500
15	Trim	Trim. mach.	......	....	....	..	....	1	..	400
16	Wash	Washing tank	......	....	....	..	....	1	1	500
17	Anneal, pickle and wash	......	......	Rockwell	1250	20	Water cooled	1	3	500
18	Fifth redraw	Bliss 12" stroke	......	....	....	..	....	1	2	450
19	Trim	Trim. mach.	......	....	....	..	....	1	1	400
20	Wash	Washing tank	......	....	....	..	....	1	1	600
21	Head	1350-ton Toledo knuckle joint press	......	....	....	..	....	2	..	500
22	Trim	Trim. mach.	......	....	....	..	....	1	..	450
23	Pierce hole	Toledo 5" press	......	....	....	..	....	1	..	700
24	Taper	Bliss 6" stroke	Lube-a-Tube	....	....	..	....	1	..	700
25	Inspect	Gages	......	....	....	..	....	1	..	500
26	Rough-face, form, chamfer, finish-face, drill, back-face, recess, tap, counterbore and trim	No. 4 Warner & Swasey	Soap and water	....	....	..	....	1	..	70
27	Finish-tap	Snyder drill press	Soap and water	....	....	..	....	1	..	530
28	Finish-ream and counterbore	Barnes drill press	Soap and water	....	....	..	....	1	..	530
29	Back-burr	Barnes drill press	Soap and water	....	....	..	....	1	..	530
30	Inspect	Gages	......	....	....	..	....	1	..	60
31	Wash and dry	Soda tanks	......	....	....	..	....	1	1	1200
32	Stamp	Noble & Westbrook	......	....	....	..	....	1	1	1300
33	Pack 100 in box	......	......	....	....	..	....	1	1	1300

Machinery

was increased to 20 degrees, which proved to be satisfactory. This gave a more abrupt angle which resulted in shooting the metal upward instead of downward. It was also found that the die worked best when the point *B*, where the angle joins the straight portion of the die, was provided with a very slight radius, just sufficient to remove the sharp corner. When this point on the die wore down to a radius of about 3/32 inch, the metal again began to shoot under the punch. After the first redraw and before annealing and pickling, the cup is washed. It is then rinsed in cold water and passed on to the second redrawing operation. This, as will be noticed at *F* in Fig. 2, extends and thins the walls of the cup considerably. The punch, as before, bears only in the corner, so as not to disturb the material in the base of the cup. In this case the drawing angle on the die is made 15 instead of 20 degrees. There are two reasons why the angle was reduced. In the first place, the percentage of reduction is considerably less; and in the second place, more drawing surface is necessary to stretch the metal evenly.

TABLE II. DATA ON CUPPING AND REDRAWING OPERATIONS

Operation	Diameter of Die in Inches	Difference Between Succeeding Redraw Dies in Inches	Reduction, Per Cent	Height of Cup in Inches	Approximate Diameter of Cup in Inches	Enlargement of Cup Over Die in Inches
Blank	5.875	.....	....	....	.....	.....
Cup	5.190	0.685	4.17	1 1/2	5.197	0.007
First redraw	5.020	0.170	3.27	1 7/8	5.028	0.008
Second redraw	4.898	0.122	2.43	2 3/4	4.906	0.008
Third redraw	4.800	0.098	2.00	3 3/4	4.806	0.006
Fourth redraw	4.725	0.075	1.56	4 1/4	4.730	0.005
Fifth redraw	4.718	0.007	0.148	5 3/16	4.722	0.004

Machinery

The shape of the end of the cup has a considerable bearing on the angle required on the edge of the drawing die. For instance, the first redrawing die was made with a drawing angle of 20 degrees. Reference to Fig. 2 will show that after the flattening operation the radius was lowered over 1/8 inch; that is, the point where the radius merges with the cylindrical part of the body was dropped that amount during the flattening operation. It was found that a slight angle—in other words, 15 degrees—on the drawing die carried the point of contact up higher on the case and started out with a smaller amount of material to stretch than was the case when the angle was greater or where the leading part of the die was made with a more obtuse angle. The die for the third redrawing operation is similar in shape to that used for the second redrawing operation, but the reduction is slightly less in this case, being 2 per cent instead of 2.43 per cent.

In the fourth and fifth redrawing operations two objects are necessary: first, to draw the walls of the case to the desired length and thickness; and second, to obtain the desired resiliency in the material. This was obtained in the following manner. The case after the fourth redrawing operation was annealed to a temperature of 1250 degrees F. for twenty minutes instead of forty, as was the case in all other annealing operations, and the same punch was used for the fifth redrawing operation as that used for the fourth, the reduction being in the die only. This ironed out the case to the required thickness and length and secured the desired resiliency.

Heading Operations

The operation of heading is accomplished on two different types of presses—hydraulic and knuckle power presses. In the hydraulic press, two heading operations are necessary, whereas in the toggle joint press three blows are required to bring the head to the desired shape and thickness. In Fig. 4 the toggle joint press method of heading is illustrated. In this case, it will be noticed that the heading punches are so made that the action is to "squirt" the metal toward the rim. For the second operation, the angle of slope on the end of the heading punch is slightly less than the first, and in the last operation the angle is forty-five minutes. This makes a head which is slightly concave, but as it is finished flush by machining in subsequent operations, the concavity does not make any difference. This method of beveling the heading punches is found necessary in order to place the metal at the rim. The pressure required for heading is 1350 tons. Reference to Fig. 4 will show that the lower face of the various heading punches, with the exception of the last, is provided with an annular groove. The object of this groove is to allow the metal to pack up at this point in order to get a smooth surface on the under side of the head in the final flattening operation. The flattening action, it will be noticed, is greatest between

Fig. 7. First Operation on Cartridge Case—Cupping—which is handled in a Bliss 12-inch Stroke Press at the Rate of 525 per Hour

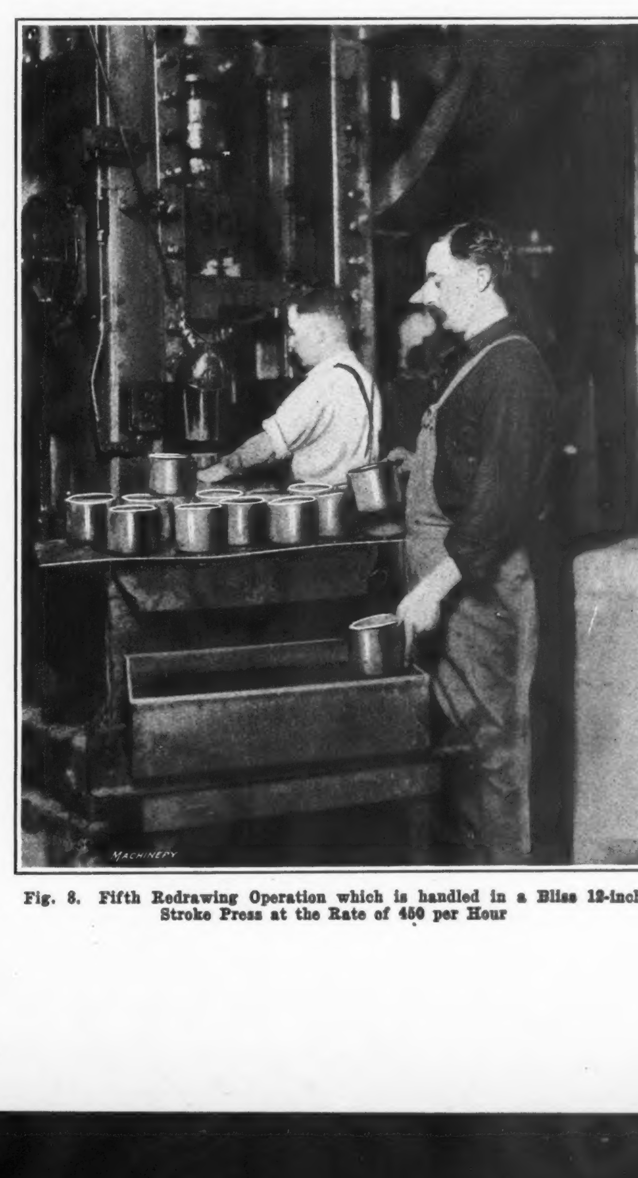


Fig. 8. Fifth Redrawing Operation which is handled in a Bliss 12-inch Stroke Press at the Rate of 450 per Hour

Fig. 9. Heading Cartridge Case in Toledo 1350-ton Press—Three Blows are required to finish Case and Two Operators attend to the Machine, One indexing the Punches and the Other inserting and removing the Cases. Production is 500 per Hour.

the two radii a and b; this tends to cause a wrinkle to be formed on the under surface located between these points, which is avoided by providing a groove in the lower face of the upper punch. The shape and size of this groove were determined by experiment, and the dimensions shown at A and B were found satisfactory.

Sequence of Cupping, Annealing, Redrawing and Heading Operations

Fig. 5 shows the sequence of cupping, redrawing and heading operations that were followed in the production of this cartridge case, and Table I lists the sizes of the machines used, lubricant, furnace, temperatures in degrees for annealing, time of annealing, cooling bath, number of operators, number of helpers and production per hour. Table II gives the approximate data covering the dimensions of the dies used, reduction between each redrawing operation in inches as well as per cent, and difference between the diameter of the die and the diameter of the case produced by it, etc. This case is made from brass of a composition about 70 per cent copper,

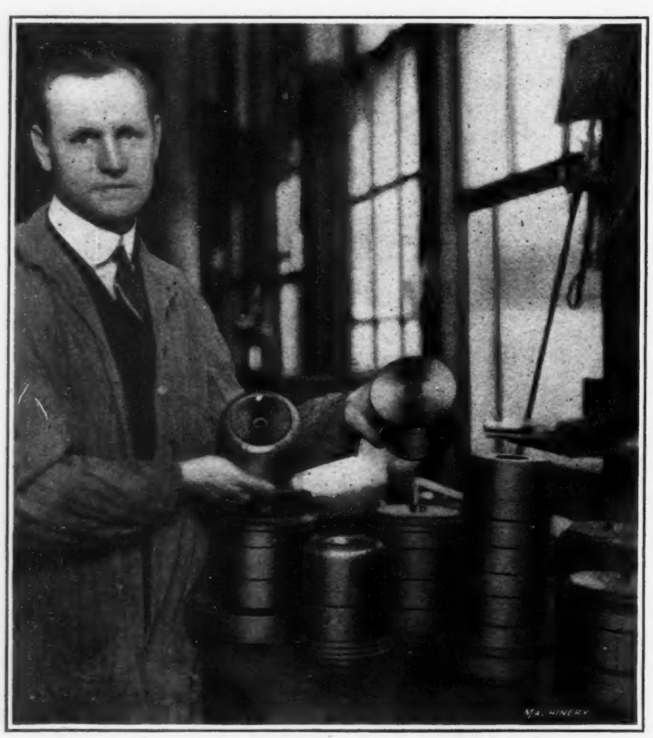


Fig. 10. Ring Built-up Type of Heading Punches—this was the Only Type of Punch that proved Satisfactory

30 per cent zinc. This percentage of zinc in the case makes it quite hard when passed through redrawing operations; consequently there is considerable spring in the material, and the cup produced is slightly larger than the hole in the die through which it is drawn. The diameter, of course, varies in different cups, depending on the thickness of the case previous to drawing and the reduction made. The enlargement of the cup over the die varies between 0.002 and 0.003 inch from the figures given in Table II, according to the hardness of the metal.

Annealing, Pickling and Washing

For annealing, 110 cups, approximately, are placed in trays, five of which are put in a Rockwell under-fired furnace, burning fuel oil at the rate of seven gallons per hour. The temperature of the furnace is kept at 1250 degrees F. and the cups are allowed to anneal for forty minutes, then removed and cooled in water. The furnace is so arranged that a tray is put in and removed every eight minutes. After cooling, the cups are immersed in a pickling bath composed of one part sulphuric acid to ten parts water. This solution is kept at a temperature of from 100 to 125 degrees F., and the cups are allowed to remain in it for from four to five minutes. They are then removed and immersed in water to remove all traces

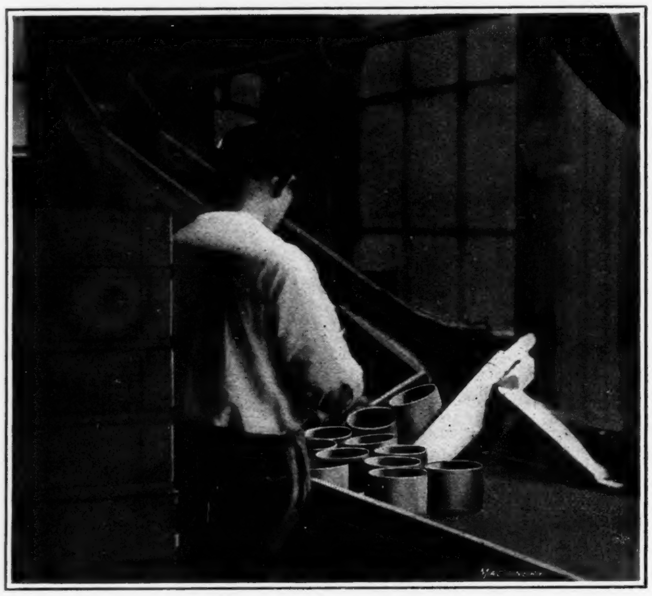


Fig. 11. One Type of Conveyor System used which carries Cases from Press to Machining Department—Inspector stands at End of Chute and gages Each Case as it comes through

of the acid. Before annealing, all lubricant and dirt is removed from the cups by immersing them in a sal-soda solution.

Trimming and Tapering

Trimming of the ragged edge is carried on between the fourth and fifth redrawing operations, after the fifth redrawing operation, and after heading. After heading, the hole for the primer is rough-punched in a punch press and the body is then tapered in a separate die. The tapering is accomplished in a simple die, and one operation finishes the case to the required taper. The following operations consist in machining the head, primer pocket and trimming off the end, after which several final operations, such as tapping and reaming, backburring, etc., are performed. The case is then inspected, washed, dried, stamped and packed. The production for each operation, as well as the number of operators and helpers required, is given in Table I.

Drawing and Heading Tools

Drawing dies in all cases are made from solid blanks of class "C" Colonial steel which has a carbon content of 0.90 to 1.05 per cent. The blanks, after being machined to the desired shape, are hardened in a strong brine solution—strong enough to float a raw potato. After hardening, the die is allowed to cool off in the bath, then removed and drawn in oil at a temperature of 400 degrees F. to remove the strains. After hardening, the die is lapped out both on the entrance and drawing

faces and is good for producing anywhere from 30,000 to 40,000 cups after each successive hardening. The first cupping die, however, produced in the neighborhood of 50,000 cups before it was worn too large. Each is hardened five successive times, and used for the next larger size, before it is found that the steel develops cracks or other defects which prevent its further use. The punches are made from a similar grade of material and are hardened and drawn in a similar manner.

The heading die ring is made of the same grade of steel, hardened and drawn, whereas the upper and lower heading punches are built up in the form of rings varying from 1⅛ to 1¼ inch in thickness, as shown in Fig. 10. It was found that the enormous pressure—1350 tons—was so great that the resistance of a solid punch was not sufficient to withstand this pressure for any length of time, and it soon upset. The theory advanced was that the steel did not harden completely through, and only a scale of, say, ⅛ inch or more of very hard material would form. This did not offer sufficient resistance to withstand the pressure, and upsetting took place. With a punch of the ring form of construction, it was possible to secure more uniform hardening, and there was less liability of upsetting.

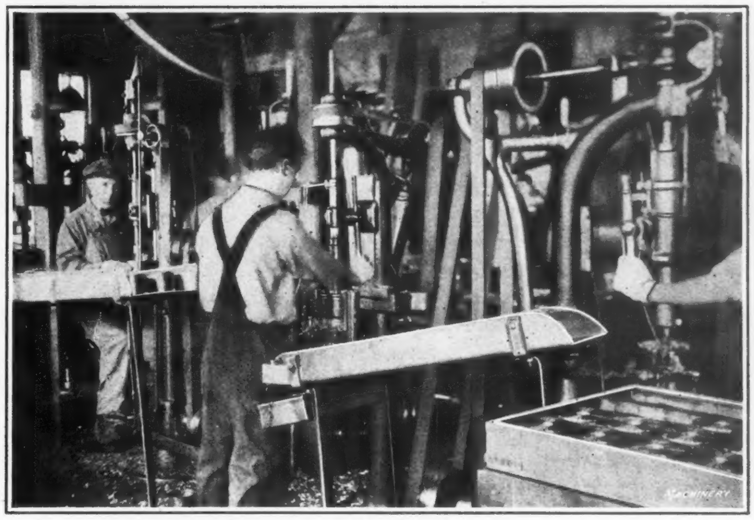


Fig. 13. Final Machining Operations, consisting in finish-reaming, counterboring, tapping, back-burring, etc. Production at Each Operation is at the Rate of 530 per Hour

Fig. 12. Inspecting Thread in Primer Pocket and gaging

Some of these sectional punches made stood up for producing about 1,000,000 cartridge cases and are still in good condition. Class "C" Colonial steel was also used for the heading punches. This had a carbon content varying from 0.95 to 1.05 per cent. After machining, the sections of the punch were heated in a Hoskins electric furnace to a temperature of 1500 degrees F. which required anywhere from 2½ to 3 hours. They were then dipped in a strong brine solution of a consistency such as to float a raw potato and were left in this until cold. They were then removed and put in pure lard oil heated to a temperature of 700 degrees F. After cooling, they were finally drawn until the lard oil would flash when placed on them. This would indicate a temperature of over 400 degrees F. After this, the punch was allowed to cool in the air.

It might be of interest here to note that there is an important difference between the behavior of fixed and mineral oils (fixed means animal or vegetable). Animal or vegetable oils do not evaporate and no vapors are given off, except possibly traces of moisture, on heating them until the oils become decomposed. The vapors then given off are products of the destructive distillation of the oil, which requires a fairly high temperature to bring it about, and consequently the flashing points of fixed oils are high—over 400 degrees F. On the other hand, all mineral or hydro-carbon oils evaporate when heated, and the temperature at which sufficient vapor is given off to cause a flash depends upon what hydro-carbons are contained in the oil. In mineral oils the flashing point varies all the way from 150 to 400 degrees F., and sometimes higher, depending upon the amount of hydro-carbon. It has been found that heading punches hardened and tempered in the manner outlined will turn out from 50,000 to 100,000 cases. They do not wear in this time, but sometimes swell out, which makes them unsuitable for use. One punch has been used for heading over 1,000,000 cases and is still in good condition.

Machining Cartridge Case

Machining of the cartridge case is performed on Warner & Swasey turret lathes and Bullard special cartridge case, facing and trimming machines. The operations performed on the Warner & Swasey No. 4 screw machine, shown in Fig. 14, are as follows: chuck, rough-face, form and chamfer, finish-face, drill, back-face, recess, tap, counterbore, and trim open end with a special trimming tool. The cartridge case runs at a speed of 400 R. P. M., except for the forming, which is done at a slower speed with the back-gears thrown in. The feed for finish-facing is 0.027 inch per revolution of the work, and the production is seventy per hour from each machine.

After these operations have been performed, the primer pocket is then finish-reamed, tapped and counterbored in drill-

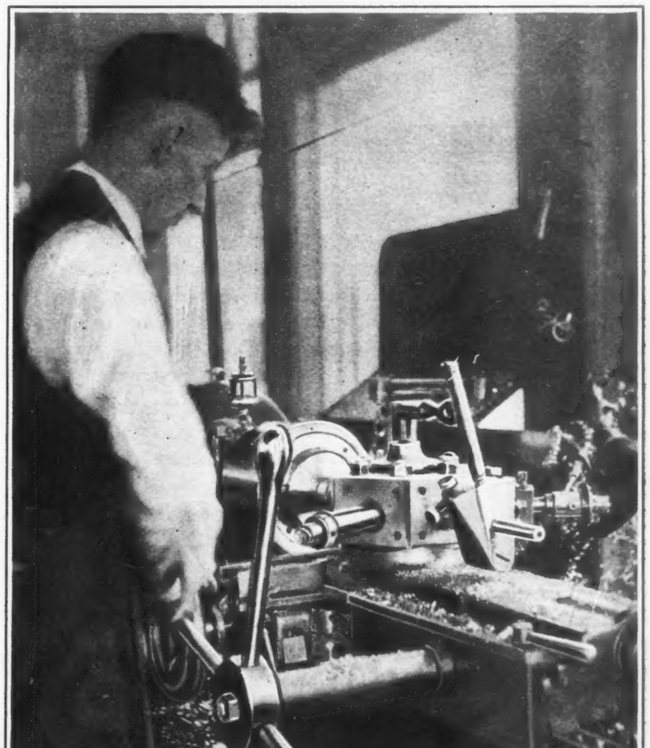


Fig. 14. Machining Head and Primer Pocket in a Warner & Swasey No. 4 Hand Screw Machine at the Rate of Seventy per Hour

ing machines, as shown in Fig. 13, in the following order: finish-tap, speed 250 R. P. M., production 530 per hour; finish-ream and counterbore, speed 200 R. P. M., production 530 per hour; back-burr the primer hole, speed 300 R. P. M., production 530 per hour.

For all of these operations the cartridge case is held in a pneumatic chuck. The cartridge case now passes on to the inspectors shown in Fig. 12, where the thread, outside diameter, etc., is gaged. If the threaded hole is found to be small, it is hand tapped. The production is sixty per hour. The case is now washed in soda water and rinsed in hot water, after which it is dried in sawdust and buffed on a buffing wheel. The next operation after the cartridge case comes from the government inspectors is to stamp it on the head in a Noble & Westbrook stamping machine, shown in Fig. 15, at the rate of 1300 per hour. This machine is also provided with a pneumatic adjustable holding device for the work, which facilitates the speed at which the stamping is accomplished. The cartridge case is then put onto a traveling chain and is carried to a point where it is packed and boxed, as shown in Fig. 16. The cartridge cases are packed in boxes holding 100, in a similar manner to that used for packing eggs. The box measures 22 by 26½ by 19 inches.

Methods of Handling Work

As was mentioned in the introductory part of this article, the Worcester Pressed Steel Co. planned to turn out 4000 cartridge cases in twenty-four hours, and eventually turned out 10,000 in this time. One of the chief reasons why such an enormous increase in production was possible was the efficient methods used in handling the work. Extensive use was made of conveyor systems, several types of which are used. In some cases only a plain chute is employed, this being the method followed when the operations are performed on machines located at close distances. Where the departments in which the various operations are accomplished are separated by a considerable distance, chain conveyors of various types are brought into use. For instance, the final punch press operation is tapering, and after tapering, the cartridge case is simply put on a conveyor and carried directly to the machining department which is in a remote part of the plant. Before passing on to machining, however, the diameter, length, etc., of the cartridge case is inspected. The inspector, as shown in Fig. 11, stands at the termination of this chute and picks up each case as it passes through, inspecting it at the points mentioned; he then places it in a box ready for passing on to the various machining operations. Owing to the short distances traveled between the first and second machining operations, trucks are used to convey the box of cases to the various machines. After this, the conveyor system is again brought into use for carrying the cases from the government inspectors to the stamping machine, and then from the stamping machine to the packing department.

Fig. 15. Stamping Head in Noble & Westbrook Stamping Machine—note Conveyor for bringing Cases from Inspector to Machine

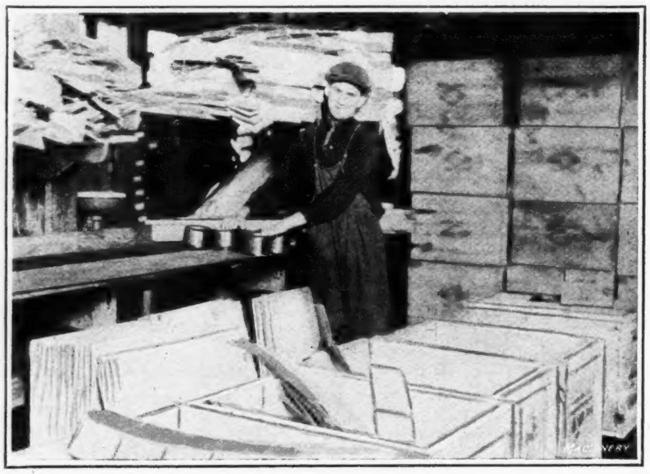


Fig. 16. Packing—note Belt Conveyor for carrying Cartridge Cases from Stamping Machine to Packing Department

Inspection and Tests

All cartridge cases receive two final inspections, which consist in looking over the cases to see if they have any defects, as well as gaging them to determine if all the dimensions are correct and up to specifications. These inspections are made both by plant and government inspectors. A number of cartridge cases are selected for what is called a proof test. The requirements are that six out of every twelve hundred are taken for a proof test. This consists in loading the cases three times, and they must be capable of resisting the enormous pressure developed by the smokeless powder after three loadings. One of these six cases is then taken and put through a destructive test. When the government inspectors found that the cases were coming good, it was finally decided that three out of forty-eight hundred, instead of six out of twelve hundred, would be sufficient for this proof test. The weight of the finished case is two pounds, ten ounces, and the blank weighs three pounds, so that only six ounces are removed by trimming and machining. D. T. H.

* * *

LEGAL HOLIDAYS

BY WILLIAM PHILIP*

Have any of the readers ever stopped to consider the field that is opened for discussion under the above title? Has this subject received the thought and consideration which it should have, especially in some sections of the country?

We have been standardizing and organizing and controlling all sort of evils (actual and fancied) of modern industry. It is my opinion that there is room for improvement along the line of legal holidays. There is no system or regulation; there are a few holidays which are celebrated in nearly all sections, but there are quite a number of holidays that are celebrated sectionally or locally, sometimes only affecting a certain town or city. For instance, if a group of men get together and decide that the town, city or state, as the case may be, is in need (?) of another holiday, they get the public officials and executives to appoint committees, declare a legal holiday, and the lid is off.

Here is where some of the dissatisfaction and confusion exists: Some establishments and plants recognize the holiday, others do not; the employes who do not get the holiday are put out about it, and in consequence it fosters ill-feeling, and even if there is no open rebellion, the men do not work up to their usual standard. Those employes who are granted the holiday also have a grievance if they are on an hourly basis; it means there will be a day's pay less the next pay day. The employer, too, has a grievance; if he grants the holiday, it disarranges his routine and production; if he does not grant the holiday, he lays the foundation for dissatisfaction, and in the end it probably would have been better had he granted the day off.

I hope the time will come when we shall celebrate holidays nationally and not in certain sections. If it is felt that more holidays are needed, they should be chosen nationally, not locally; and the closing of manufacturing plants should also be general.

* Address: Box 155, South Orange, N. J.

TREPANNING HEAVY CYLINDRICAL FORGINGS

BY W. R. B.

The operation of trepanning consists of cutting out material from the solid in such a way that the core is left intact, a comparatively small amount of material being formed into chips during the process of trepanning. In making large guns, the cost of material is an important factor, and for this reason the process of trepanning is also frequently resorted to in order to save the inner core. The process was much more prevalent before the invention of large hollow forgings for the A-tubes of large guns, which extend from muzzle to breech and contain the chamber and the rifling. Liners for the recoil cylinders of large gun carriages can also be trepanned at a profit. The first hollow gun forgings were made by the Sir Joseph Whitworth Co., Manchester, England, this company being later absorbed by the Armstrong Mitchell Co., Newcastle-on-Tyne, England.

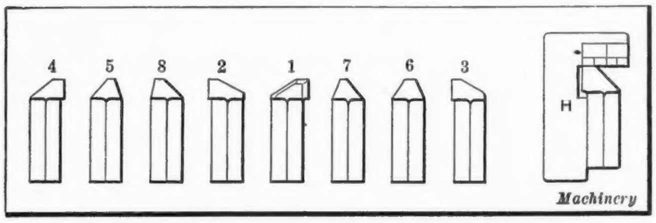


Fig. 1. Tools and Gage used with Bar shown in Fig. 2

Trepanning can be done to advantage in a hollow spindle lathe having carriages to which boring-bars are applied and which are operated from each end of the gun simultaneously. In the course of general manufacturing, many parts are made which can be profitably trepanned, providing the tools are properly arranged, instead of drilling out the stock from the solid. It is essential, however, that a man be perfectly familiar with this kind of work in order to secure the best results, and it is somewhat difficult to find an operator who is an expert on trepanning, as many good machinists have been unsuccessful in handling this kind of work. This may have been partly due to the fact that the operation of trepanning is not by any means a simple or an easy one, and it is necessary at times to put in some good hard work as well as practical experience in order to obtain the desired results. In addition to this, there is always a chance for the operator to get a good "ducking" from the lubricant when at work.

Trepanning Cutter-head and Bar for 10¾-inch Holes

The cutter-head and bar shown in Fig. 2 is designed to trepan a core about 9½ inches diameter and a bore of 10¾ inches. It is obvious that the length of the bar is determined by the work to be done, the one shown being about 30 feet long. The bar is guided by bushings located in brackets on the bed of the lathe and is fed forward by the movement of the carriage.

The water pressure pipe is held stationary in a bracket at *C*, the outlet end being three or four inches from the face of the forging. The pressure should not be less than 200 pounds per square inch, and an even higher pressure than this will be found advantageous in forcing out the chips along the channels *E* provided in the tool. The tools used in the cutter-head are shown in Fig. 1. A set of tools is made up to each one of the different styles of points shown, and after these are made they are ground to fit the gage *H*.

By referring to the group of tools shown, it will be seen that the cutting points are so arranged as to break the chip to good advantage. This is an extremely important point in connection with work of this kind, as it is necessary to make the chips of such a size that they will be washed out through the grooves provided for them at *E* along the outside of the tool body. The corners *F* are cut away in order to assist this action by leading the chips easily into the grooves. The tools which cut the outside and inside diameters must be watched more closely than the others, as the former are for sizing the burnishers, while the others are to clear the core. The shapes to which the tools are ground depend entirely on the kind of material which is being cut, but the proper shapes are soon learned by any man engaged in trepanning. A piece of rod small enough to go easily up the groove *E* should always be at hand in case the chips need "tickling" to prevent their packing into the grooves when forced out by the lubricant.

The method of holding the bar or cutter-head must be such that the tension can be adjusted so that it will resist the cutting action without slipping, and yet will revolve before a breakage occurs in the event that any particularly hard cutting is encountered. The inserted pieces shown at *D* are made of *lignum vitae* and are used for burnishing the inside of the tube. These burnishers are soaked in oil before use, and the longer they are soaked the better will be their action. They should project from their recesses about 1/16 inch beyond the outside diameters of the cutters. They can be raised for repacking by means of the chamfered portion at the end and can be easily replaced after the repacking has been completed.

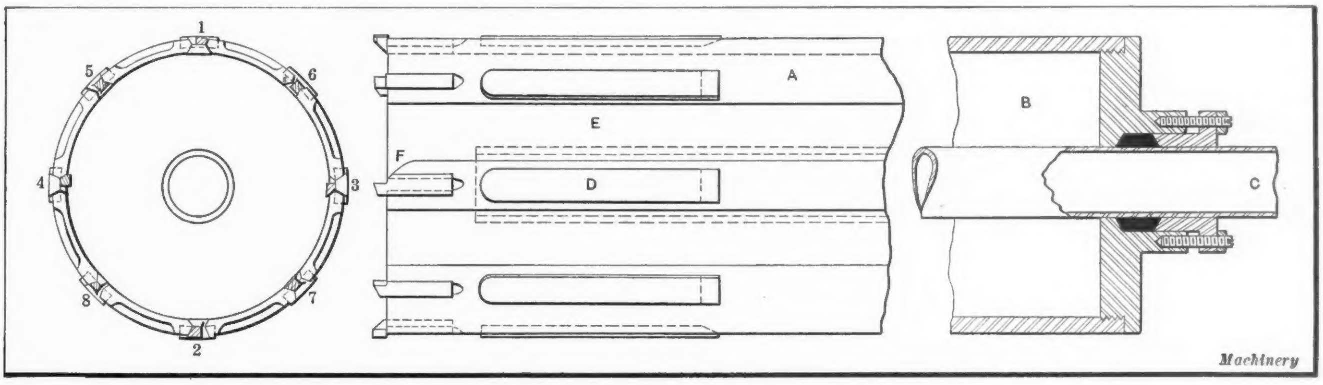


Fig. 2. Trepanning Bar for a Big Gun Tube

Important Points in Trepanning

When preparing the cutter-head for its work on a new forging, a ring is first made on the face of the work, each cutter being carefully inspected to see that it is taking the proper amount of chip and doing its share of the work. This is quite important, as the breaking of the chips allows them to be washed out through the grooves along the driving tube. The outer edge of the ring made in testing the tools is jagged with a cold chisel in such a way that the projecting teeth will form cutting edges to turn the burnishers to size.

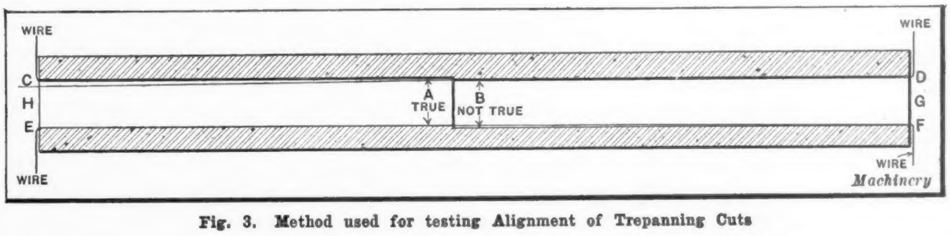


Fig. 3. Method used for testing Alignment of Trepanning Cuts

Fig. 3 shows a section taken through the tube, and the method by which the straightness of the bore can be determined is clearly shown. A fine wire drawn tightly from *E* to *F* and striking continuously all along the surface bored from the face marked *H* will clearly show the interruption at the junction of the two cuts which are machined from each end of the tube. In the same manner the wire when stretched from *D* to *C* shows that the bore started from the end *G* has not run straight. In order to determine these points, the use of an incandescent bulb on the end of a fish-pole or something of a similar nature may be necessary in order to throw the light into such a position that the points of contact and variation in the straightness of the wire can be easily seen by the operator. By determining these points before the boring operation, the centering of the work for subsequent cutting can be more easily accomplished.

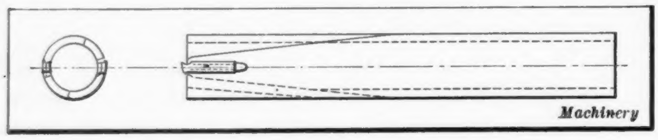


Fig. 4. Construction of Trepanning Bar for Small Work

Small Trepanning Tools

Various kinds of small trepanning tools are used, but there is nothing better for this purpose than a piece of pressed steel tubing with inserted cutters, as shown in Fig. 4. The cutter seats and tools for them are easily made and can be quickly replaced if necessary. It is obvious that the tools should always be thicker than the tube in which they are used. For example, a tube 1/8 inch thick would require tools to be made about 3/16 inch square in order to give sufficient back clearance. Small cutters of similar kind have been made from a solid piece of tool steel, turned and drilled as required and having one cutting edge at the end of a slot which is provided for the chips. This method of making a small trepanning tool is costly, as the tool must always be wider at the cutting point and it must be backed off or have back clearance so that it will not drag, as the life of the tool depends entirely on the cutting point.

The number of cutting points used in any trepanning operation is an important factor, as the cutting action is much better with a number of tools working at once and the chips are smaller and more easily forced out along the grooves provided for them. The number of teeth should always be proportional to the strength of the bar and the slots in which they are held.

* * *

MAKING DRILL JIG BUSHINGS

BY ERIC LEE*

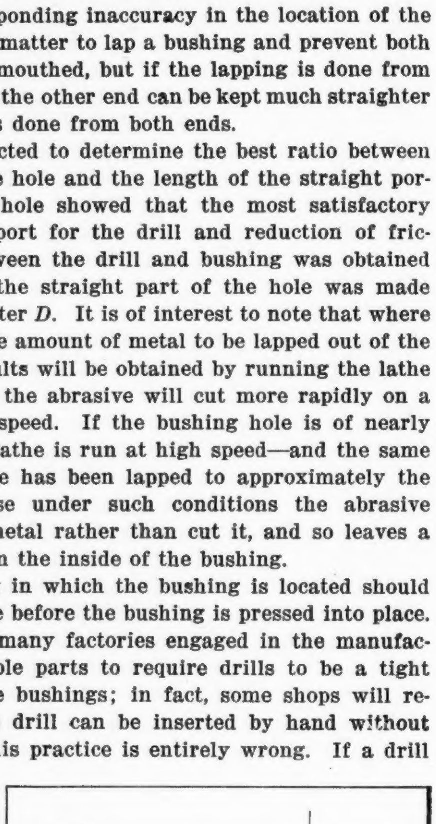
We experienced considerable difficulty in securing drill jig bushings possessing the required durability, and experiments conducted to determine the cause of the trouble showed that both the grade of steel used and the way in which the bushings were made were at fault. Our drill jig bushings were for drills from 1/16 to 5/8 inch in diameter, and the jigs were used for drilling holes in interchangeable gun parts. The form of bushing which we use is shown in the accompanying illustration, and in the following article is outlined the method of making these bushings which we have found to be most satisfactory.

For the purpose of discussion, we will consider the making of a bushing for guiding a ⅛-inch drill. The stock was turned down to a diameter of ⅜ inch for a sufficient distance to allow the stem of the bushing to pass through the wall of the jig and come within 1/16 inch of the work to be drilled. The piece to be drilled is made of steel, and experience has shown that it is advisable to bring the bottom of the bushing as near the work as possible, in order that the drill may have exactly the proper location and insure interchangeability of parts. If the work to be drilled had been made of cast iron, the bushing would have been made shorter in order to allow more space between the bottom of the bushing and the work for the clearance of chips.

In making bushings, when drilling a hole to finish to a diameter of ⅛ inch, a No. 31 drill is used. After drilling the hole, we use a flat taper reamer to form the bell mouth; and finally a rose reamer is employed, which is made out of a piece of 0.127 inch drill rod turned down to a diameter of 0.1235 inch, which leaves about 0.0015 inch on the side of the hole for lapping. It is important that the hole be reamed as smooth as possible in order to cut down frictional resistance between the drill and bushing to a minimum. The next step is to harden the bushing glass-hard and then test it with a plug gage. After the size of the hole has been ascertained in this way, the bushing is put into the chuck of a speed lathe and lapped from the bell-mouthed end *A* with a split copper lap charged with emery of about 120 grade. The inside end *B* of the bushing should be kept as straight as possible, as the formation of a bell mouth at this end will result in danger of a corresponding inaccuracy in the location of the drill. It is a difficult matter to lap a bushing and prevent both ends from being bell-mouthed, but if the lapping is done from the bell-mouthed end, the other end can be kept much straighter than if the lapping is done from both ends.

Experiments conducted to determine the best ratio between the diameter *D* of the hole and the length of the straight portion of the bushing hole showed that the most satisfactory balance between support for the drill and reduction of frictional resistance between the drill and bushing was obtained when the length of the straight part of the hole was made three times the diameter *D*. It is of interest to note that where there is a considerable amount of metal to be lapped out of the bushing, the best results will be obtained by running the lathe quite slowly, because the abrasive will cut more rapidly on a low than on a high speed. If the bushing hole is of nearly the desired size, the lathe is run at high speed—and the same applies when the hole has been lapped to approximately the required size—because under such conditions the abrasive tends to polish the metal rather than cut it, and so leaves a fine smooth surface on the inside of the bushing.

The hole in the jig in which the bushing is located should have a smooth surface before the bushing is pressed into place. It is the practice in many factories engaged in the manufacture of interchangeable parts to require drills to be a tight fit in their respective bushings; in fact, some shops will reject a bushing if the drill can be inserted by hand without the use of pliers. This practice is entirely wrong. If a drill is a snug fit, that is quite sufficient, and if the size of the bushing is such that it requires the use of a pair of pliers to push the drill into place, it is evident that either the drill or bushing will be under considerable strain while in operation, which, of course, should be avoided.



Approved Design for Drill Jig Bushing

As the bushing is considerably harder than the drill, it is reasonable to conclude that the drill is compressed, with the result that the holes are drilled under size until the bushing has been worn sufficiently to allow the drill to run under normal conditions. If the hole in the bushing is made of a size to afford just a snug fit between the drill and the bushing, the chips will free themselves more rapidly and the bushings will last much longer. As extreme accuracy is required in the drilling of interchangeable parts, it is important to provide for the replacement of drill jig bushings in the shortest possible time in order to avoid unnecessary delay in the process of manufacture. This point can be satisfactorily taken care of by keeping a supply of various sizes of bushings which can be substituted in the drill jigs as the necessity arises.

* Address: 195 Bassett St., New Haven, Conn.

GRINDING WHEEL SPEEDS

BY H. W. DUNBAR*

There is a popular notion that the greater number of revolutions the grinding wheel can make the greater will be the production. This is a mistaken idea when applied to machine grinding, although in hand grinding—where the act of the operator must be taken into consideration—it is usually true that the greater the speed of the wheel is, within the recommended limits, the greater will be the production. But if the wheel were stronger or harder and run at a slower speed, the operator would produce the same amount of work if he were to use greater pressure. The speed of the grinding wheel must be always relative to its own strength of particles and bonds, the size of its grain, the kind of material being ground, and the amount of force exerted by the operator when hand grinding, or depth of cut or amount of work done when machine grinding. In cylindrical and surface grinding the speed of the work and work-table are the limiting factors controlling the amount of work that can be done per minute, whatever the wheel and whatever the speed of it. So that within the range of grades in wheels that is known today, and the range of speeds of table and work on the machine, and the variety of materials being ground, we can vary the speed of the wheel within very wide limits and still accomplish the same amount of work.

To illustrate: a speed of 6000 surface feet per minute is commonly used on wheels for cylindrical grinding machines, but on a very successful surface grinding machine 4000 surface feet per minute removes an equal amount of material in the same time as that removed on the cylindrical grinding machine, in many cases, with the wheel revolving at 6000 feet per minute. In the case of surface grinding, where the arc of contact is so much greater than in cylindrical grinding, it becomes necessary to use a softer wheel and to adopt a slower speed in order to prevent the wheel from burning. In one case it has been found practical to use as low a surface speed as 2000 feet per minute. While it is not physically possible, if we could obtain the grains of grinding material and a bond of sufficient strength, it would not be necessary to revolve the wheel at all. The work could be forced against the grains which would act just as a planer tool does so that the material would be removed. But inasmuch as it is not physically possible to have this strength of particles and bonds, the wheel must revolve in order to distribute the work over many particles in the same time. Hence, the softer or weaker the wheel, the faster it must revolve if it is not to be worn away too rapidly; and conversely, the harder and stronger the wheel, the slower it may revolve and not be worn away too rapidly.

If it were mechanically practical to traverse the reciprocating table of a surface grinding machine 100 to 200 feet per minute, the grinding wheel that is now used at 4000 feet per minute would do more work in the same time if it revolved at 8000 or 9000 feet per minute. But it is neither mechanically possible to traverse the table at such a speed nor physically possible for such a wheel to be revolved at that speed with safety. Different kinds of material being ground cause the wheel to do more or less work, and accordingly affect either the speed of the work or wheel, or the grain and grade of the wheel. It is immaterial what the grain and the grade of the wheel is—within reason—as the speed will always regulate the amount of production or compensate for the variation in grade and grain. Different wheels will grind different materials by using different wheel speeds, but the speed of the wheel must always be relative to its own grade and grain, the kind of material being ground, and the amount of work being done; which brings us back to the same point from which we started, as the whole question is only a relative one and the wheel speed is only important as it relates to the physical possibilities of the wheel and the amount of work that it can accomplish. Do not get the idea that any wheel you may have may be revolved successfully at any speed, at any time, with any work. Speed must be relative to the other factors. But there is no fixed speed for wheels simply because they are grinding wheels.

* Address: 117 Lincoln St., Worcester, Mass.

MACHINING AN AUTOMATIC SPRINKLER HEAD

The following method is suggested in response to an inquiry for a method of machining the automatic sprinkler head *A* shown in the accompanying illustrations. The inquiry states that the use of an automatic machine is not to be considered, and therefore the method of handling shown in Figs. 1 and 2 is applied to a hand screw machine.

First Setting

Operation 1.—The work shown at *A* in Fig. 1 is made of brass, and it is to be held for the first setting in a two-jawed chuck having special jaws *B* which are grooved to receive the arms on each side of the casting, thus centering the work and providing a fixed longitudinal location. The first operation, as shown in the upper illustration in Fig. 1, consists of spotting the ends of the work with a spotting drill of the flat type, as shown at *D*, and at the same time chamfering the end of the piece in preparation for the turning operation, by means of the tool *C* inserted in the holder *E*. A holder of this kind can be easily made with a shank of suitable size to fit the turret hole.

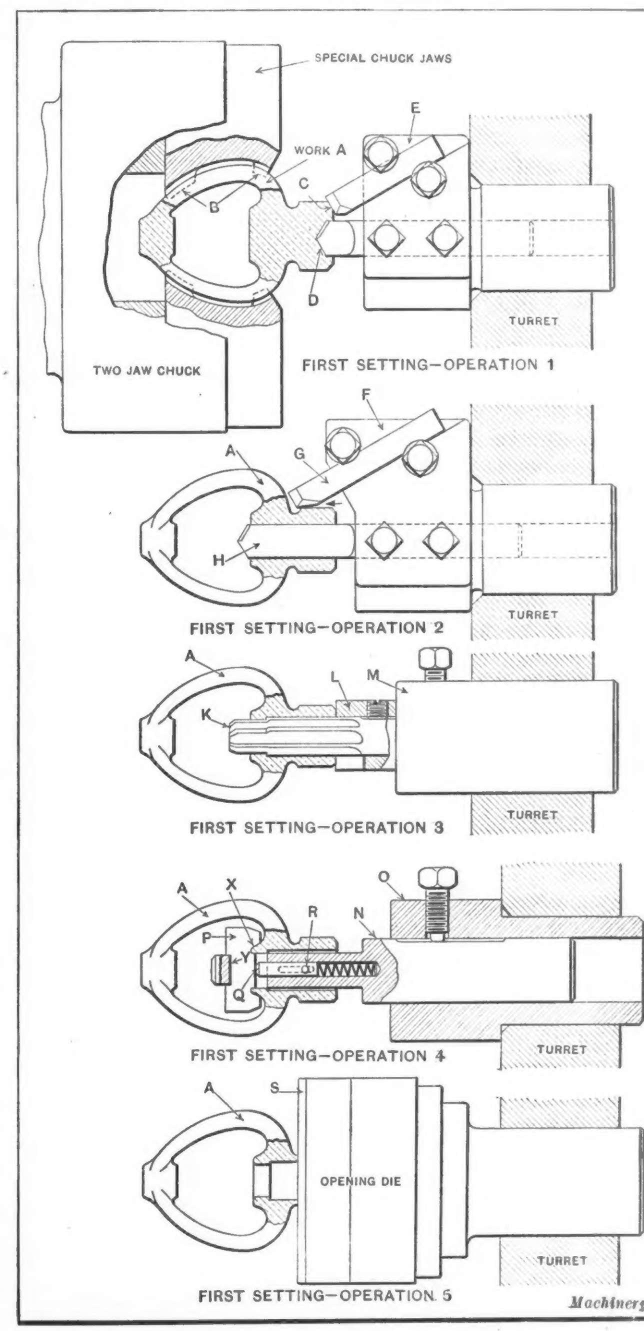


Fig. 1. Operations in First Setting of Sprinkler Head

Operation 2.—This operation consists in drilling the hole previously spotted with a flat drill *H*, at the same time turning

the outside diameter with a tool *G* held in the holder *F*. This holder is similar to that used in the first operation.

Operation 3.—In this operation the reamer *K* is used to finish the two inside diameters, and the face mill *L* cleans up the ends of the casting. The mills and reamers are held in a toolholder *M* located in the turret.

Operation 4.—This operation consists of back-facing the inner surface, using a special tool provided with an inserted-blade cutter *P*, having the required form *X*. This tool is inserted in the holder *N* and is so fitted that it can be located by the shoulder at *Y*. It is held in place by the spring plunger *Q* which is restrained in its movement by the pin *R* working in the slot shown. It is advisable to cut away one side of the chuck a trifle in order to enable the operator to put his fingers in and manipulate the cutter blade *P*. In operating this back-facing tool, the workman first brings the turret forward to a point which permits the insertion of the blade; after this, he carries the turret back until it has reached a predetermined point, thus producing the contour shown at *X*.

Operation 5.—The final operation on this piece is the cutting of the thread on the end of the piece by means of the opening die shown at *S*. The opening die can be set in such a way that it will open at the correct position so that the thread will be cut to the desired length. The thread may also be cut by means of the regular die held in a releasing die-holder, and satisfactory results can be produced by this method, although it requires a reversal of the spindle to back the die off the work. This completes the series of operations for the first setting of the work.

Second Setting

The method of holding the work for the second setting and the sequence of operations with the necessary tools are shown in Fig. 2. Referring to the upper illustration, the method of holding is by means of a special arbor on which the work *A* is placed. The arbor is keyed at *D* in the special nose-piece *B*, and is drawn back into position by the nut and washer *E*. The shoulder *C* on the arbor acts as a stop for the finished end of the work, and the nose-piece is provided with driving arms *H*, in which set-screws *G* are so placed as to contact against the flatted portion of the work. These set-screws can be provided with check-nuts and set up so as to just come against the rough casting and act as drivers, also, to a certain extent, preventing vibration in the work. The work is held in place by means of a nut and a C-washer *F*.

Operation 1.—The first operation consists in spotting the ends of the piece preparatory to drilling, using the flat drill *L*, held in the regular type of holder *K*.

Operation 2.—This operation consists in drilling the tapped hole with the flat drill *M*, which is held in a holder like that in the previous operation. The facing of the ends of the work is done by a tool *Q* on the cross-slide of the machine. This may be operated simultaneously with the flat drill by turning the drill in such a position that the tool can pass the inner edge of the work without interference.

Operation 3.—This operation is simply tapping out the previously drilled hole with a tap *O* held in the releasing tap-holder shown in the illustration Fig. 2.

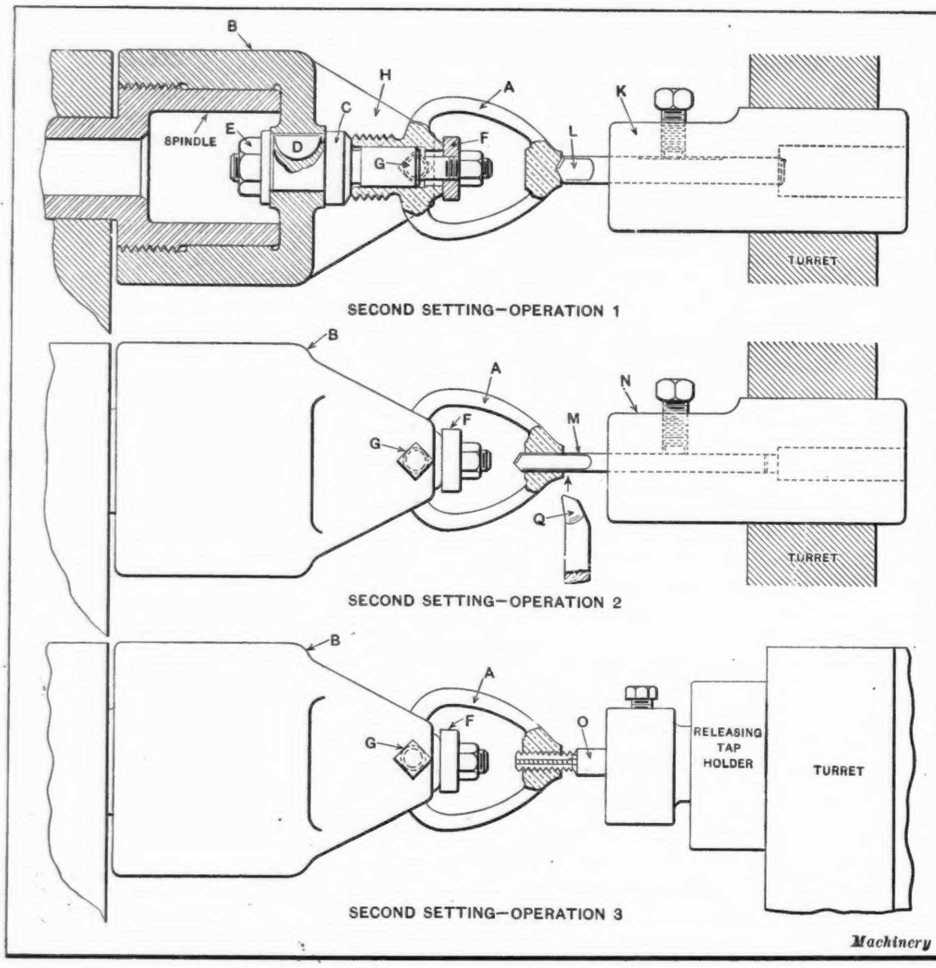


Fig. 2. Operations in Second Setting of Sprinkler Head

The tools shown in the series of operations described are simple in design and can be manufactured or adapted from other tools of similar kind with comparatively little work. The fixtures are not difficult to make, and the only operation requiring any special care is the back-facing operation shown in Fig. 1. The production for the first setting should be about 75 pieces per hour, assuming that a cutting speed of 150 to 200 feet per minute can be used. The second setting can be done at the rate of 140 pieces per hour, assuming a cutting speed of 150 feet per minute. Much depends upon the skill of the operator in the matter of production when a hand screw machine is used, and a capable man may easily secure an output considerably greater than that mentioned after he has worked on the job for a sufficient length of time to become thoroughly proficient in making the various settings needed on this work.

A. A. D.

* * *

LEARNING THE MACHINISTS' TRADE IN SIX EASY LESSONS!

Once in a while there is something of interest to be learned from a visit to a second-hand machinery dealer. Not long ago I happened into the office of a Connecticut machinery dealer and asked the customary question:

"What's new?"

"Have you heard about our new machinists' school that is turning out machinists for $25?" asked the machinery man.

"I should say not; tell me about it."

"There is an enterprising Italian over on the east side who realizes the dearth of machinists and is making a little money out of it. He advertised to teach the machinists' trade in six lessons of four hours apiece for the nominal sum of $25, payable in advance. He had no trouble in getting a class of twenty men together, and with the advance tuition fees bought three cheap lathes, a shaper and a drill press, and they are well under way now. Don't ask me what kind of machinists those chaps will be after their six easy lessons. Some of them may be able to put a piece on centers and take a roughing cut, but I don't believe any of the first-class machinists of the city need worry about their jobs being taken away by the products of this school."

C. L. L.

NOTES ON THE MACHINERY INDUSTRY IN GREAT BRITAIN

IMPORTATION OF MACHINE TOOLS—GENERAL INDUSTRIAL CONDITIONS—TRADE STATISTICS—WAGES

BY ALEXANDER LUCHARS*

ENGLAND presents much the same appearance as before the war. There are more women in the fields, running "lifts," as conductors of 'buses and in many other occupations formerly monopolized by men; fewer civilians to be seen, and soldiers, soldiers everywhere—all in khaki instead of the brilliant colors we used to see. The restrictions on "alien friends" are few and entirely reasonable. Within certain necessary limits they enjoy almost as much liberty as before the war—which is saying a great deal.

There appear to be no restrictions in regard to the sale or consumption of food. The cost of living has increased from 25 to 30 per cent, but the advance is confined principally to such commodities as have advanced almost as much with us.

The restrictions on imports of every kind—but especially machine tools and supplies—are very stringent; but this is grim war, on which depends the nation's existence. The agent of a well-known American concern recently obtained an order for six machines. He was allowed to send an order home for one only, and when that one arrived he was not allowed to deliver it to his customer, but to an entirely different plant where it was needed on government work. No complaint was made of this; it was related simply as a necessity of war conditions. Another equally well-known American concern, making machines urgently required in the manufacture of shells and similar material, had completed a large, up-to-date factory soon after the war broke out. The government took it—and, of course, paid for it—but the American owners are probably still thinking of the profits they might have made. All the machine tool manufacturers are "controlled" by the Machine Tool Committee of the Ministry of Munitions, which directs how their plants shall be employed and where their output shall go. This committee is comprised of well-known machinery manufacturers and merchants, all of whom give their entire time, and in some cases that of their executives, without any compensation, to the service of their country.

Immense factories continue to be erected for the manufacture of munitions, and this enormous output requires more machine tools, probably to replace those worn out; which accounts for the fact that many of the principal manufacturers in that line are still turning them out instead of making munitions.

Controlled concerns are those whose product is entirely disposed of by the government, and they are not allowed to sell or deliver any portion of it except under government direction. They are permitted first to retain their average annual profit, covering a period of two years previous to the war; but on all excess profits the government takes 80 per cent, leaving 20 per cent for the manufacturer. Other limited liability companies, which include virtually all the manufacturing concerns except the very smallest, pay to the government 60 per cent of their profits in excess of 6 per cent on their capital, or an equivalent in another form which virtually amounts to the same rate, the government taking the position that no one should expect to make more profit in time of war than is allowed by the above provisions. In addition to the percentages deducted by the government, a war income tax of 25 per cent is levied on all profits of every kind.

There were, on July 4, 3916 controlled concerns in the machinery, iron, steel, and other metal industries. How many uncontrolled small manufacturers are working for the controlled firms no one knows. One manufacturer who had eight others working for him said there were 3000 such small concerns; but that figure seems excessive, as there are only about 9000 manufacturers in metal, large and small, in the United Kingdom.

As stated above, many machine tool builders are not working on shells or gun work, but are turning out their regular line of machine tools, for which there seems to be a constant and increasing demand from the government. Many, but not all, of the machine tools employed in manufacturing munitions are subject to very severe use. One lot of 150 or more American metal-cutting machines which have been running for twelve months or more, I was told, had not yet become acquainted with a lubricant of any kind.

It is not allowed to finish the rough parts of machine tools. They are all painted a sort of chocolate color without filling or finishing. One concern I visited affixes a plate to each tool now turned out, stating that it was finished in accordance with government requirements, so that they may not suffer from future comparison with highly finished tools.

Manufacturers whom one would not think of as making war material are busy on what may be called indirect war products. One machinery manufacturer received an order from a maker of string and fish net, and doubted if permission would be given him to fill it; but on application to the Ministry of Munitions was told to rush the order through, as the machine was needed immediately—the use was not stated. When one considers the number and variety of industries producing war material of one kind or another, including coal, iron and gold mines, textile mills, chemical works and distilleries now making explosives, clothing, and the great variety of material required by the armies, the figures given in the following tables showing the comparative amounts manufactured during peace and war years, including those furnished by the Allies, do not seem excessive:

	Annual Average in Peace Years	Total Aug., 1914, to March 31, 1916
Cloth, woolen, worsted, yds	1,149,000	117,000,000
Flannel, yds	1,234,000	84,000,000
Cloth, cotton, yds	632,000	194,000,000
Boots, pairs	227,000	21,750,000
Jacket, service dress	78,000	11,490,000
Trousers	92,000	11,004,000
Frocks, khaki drill	58,000	1,134,000
Trousers, khaki drill	73,000	1,167,000
Pantaloons	13,000	2,507,000
Greatcoats	34,000	4,836,000
Caps, service dress	222,000	11,088,000
Socks, pairs	980,000	54,684,000
Cardigans and jerseys	77,000	7,555,000
Drawers, woolen and cotton	194,000	23,144,000
Vests	......	8,855,000

Great Britain is at present one vast workshop turning out war material. Although civilians continue to wear clothing and to consume or use material of various kinds, industries that are not connected directly or indirectly with the production of war material are inactive, and they may well be, because there are very few workmen to keep the wheels moving.

Considerable business is being done in "caterpillar" tractors, a development of the American farm tractor, but many times heavier, for use in dragging heavy guns to the front—and sometimes the other way. Our manufacturers might have had more of this business. An order has just been issued suspending the imports of American motor trucks, as these are now being turned out in sufficient quantities by British makers. Even the import of parts necessary for repairs of these vehicles is prohibited. Very few automobiles are being made in Great Britain, and the prices of these are naturally very much higher than before the war—the Rolls-Royce, a high-class car, sells for £1250. But for the restrictions on all kinds of imports and on the use of petrol (gasoline) our automobile manufacturers would have an unusually large and profitable field there at present.

According to the official figures furnished me on July 19, there were 2,468,000 women employed in various factories in the United Kingdom, of whom 265,000 were employed in the metal industries. The total number of men employed in the metal industries on the same date was 1,978,000.

The percentage of women employed in machine shops varies from five to ninety, the smaller percentage being on heavier work. In several shops turning out high-grade work the

* Publisher of MACHINERY.

average is ten per cent. On light munition work, such as fuses, nearly all the employes are women. It is really astonishing what heavy work women can handle. All these are earning wages which they never dreamed of before, and when the war ends and munition work is no longer required except in government arsenals, the return to conditions that existed before the war will involve an industrial revolution.

The war situation calls for various adjustments, some of which are not made without considerable difficulty. Controlled firms are permitted to build additions and extensions to their factories and to retain from their excess profits the difference between the former cost and present cost of building (which is nearly double what it was before the war). Among the advances in costs I noted that the wood for packing-cases has increased 600 per cent.

The labor situation in Great Britain has developed in a peculiar way since the beginning of the war. When it became necessary to speed up the production of munitions, an agreement was made between the leaders of the various parties in the House of Commons that the profits of manufacturers on munition production should be limited as before stated, and that the wages of the men should not be advanced beyond the prevailing rate either for day work or piece work. To insure a permanent supply of labor, the workmen are required to obtain a "leaving card" before leaving their employers, without which no one else can employ them. These agreements were enacted into law. But the demand for labor on munitions became so urgent that thousands of unskilled, non-union workmen and women were taken into the munition factories, and as they became proficient they were able to produce piece work in much less than the liberal time allowance provided by the unions, and as their efficiency further increased, they earned wages far in excess of the skilled men, who were generally employed on special work, such as toolmaking, etc. So it frequently happens that an unskilled hand, after he has six to twelve months' experience in the shop, may be earning twice what the skilled toolmaker is who furnishes him with his tools and sets them up.

The following tables give basic rates of wages before the war and at present, but under the bonus and premium system mentioned hereafter, actual earnings are very much greater today:

BIRMINGHAM AND DISTRICT RATE, PER WEEK OF 53 HOURS

	Pre-War			Present Time		
	£	s.	d.	£	s.	d.
Turners	2	0	0	2	3	0
Fitters	2	0	0	2	3	0
Drillers	1	14	0	1	17	0
Planers	2	0	0	2	3	0
Patternmakers	2	2	0	2	5	0
Smiths	2	0	0	2	3	0
Toolmakers	2	0	0	2	3	0

SCOTLAND—CLYDE DISTRICT, PER HOUR

	Pre-War d.	Present Time d.
Turners	8½	9½ to 10
Planers	8½	9.33 to 10
Machine Drillers (rate varies)	6 to 8½	7 to 9½
Fitters	8½	9½ to 10
Smiths	8¾ to 9¼	9¾ to 10¼
Toolmakers	8½ to 9	9½ to 10
Patternmakers	9	10

A large proportion of all workmen are employed on the bonus and premium system, under which, with overtime, some men make as much as 70s. per week. The most skillful piece hands are making from £5 a week up. An extreme case was mentioned of a boy about seventeen years old in the Birmingham district who made £7 a week, but for how many weeks was not stated. Many exaggerated statements are made about wages women earn.

The government order applying to controlled firms engaged in the production of arms, ammunition, ordnance, and in all branches of mechanical engineering and shipbuilding, specifies that the new rates for women shall be: 18 years and over, 4½d. an hour; 17 and under 18, 4d.; 16 and under 17, 3½d.; under 16, 3d. Women and girl workers in danger zones are to be paid ½d. an hour in addition to these rates. Allowances for processes which are dangerous or are injurious to health will be decided on the merits of the case. The same proportionate increase for overtime, premiums and bonuses applies to women as to men.

Numbers of outside manufacturers have gone into the machine tool line—one large "boot" making concern having produced a lot of grinding machines, and, of course, many more have gone into the manufacture of lathes; but this condition will be only transitory. These concerns realize that they are not equipped to turn out machine tools and cannot do so profitably against the competition of manufacturers who have been in the business for years and have established reputations. Moreover, their articles of incorporation do not allow them to manufacture anything except what is specified therein. The manufacture of machine tools by outside concerns has been limited to such machines as the greatest demand existed for, and of the more simple construction. Milling machines, automatics, turret lathes and other machines in which difficulties of manufacture are considerable, have therefore not been taken up. There are at present no manufacturers of automatics and similar high-class machines, and only one established manufacturer of grinding machines.

I believe that the demand for high-grade American tools will continue after the war, but the cheaper lines made by American manufacturers of little reputation, some of whom have lost that little by their treatment of buyers here, will be eliminated.

* * *

SHELBY SEAMLESS STEEL TUBING FOR BORING-BARS

It may not be generally known that seamless steel tubing can be used to good advantage for turret lathe boring-bars. The T. L. Harkins Machine Co., Boston, Mass., recently had a large order of boring-bars in which seamless steel tubing was employed with satisfactory results. Fig. 1 shows the tubing used. The bar is 40 inches long, and it was required to be 2⅛ inches outside diameter and have a ¾-inch hole

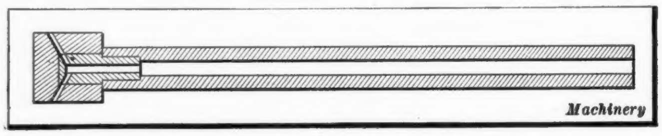


Fig. 1. Construction of Boring-bar to be made

through the center to transmit lubricant to the cutting point. The end of the tube was bored out to receive a plug that carried the tool head.

It is apparent that to machine this bar from solid stock, and especially to drill the ¾-inch hole through the entire length, would be a slow and difficult job. Shelby steel tubing was used for these bars, selecting a size with a ¾-inch hole and ¾-inch walls. Fig. 2 shows the turning of these boring-bars; it indicates extreme toughness of the material, and yet the chips show that the metal cuts freely.

By using seamless steel tubing for these bars, time was saved as compared with machining from solid stock, and a stronger, tougher boring-bar was obtained. C. L. L.

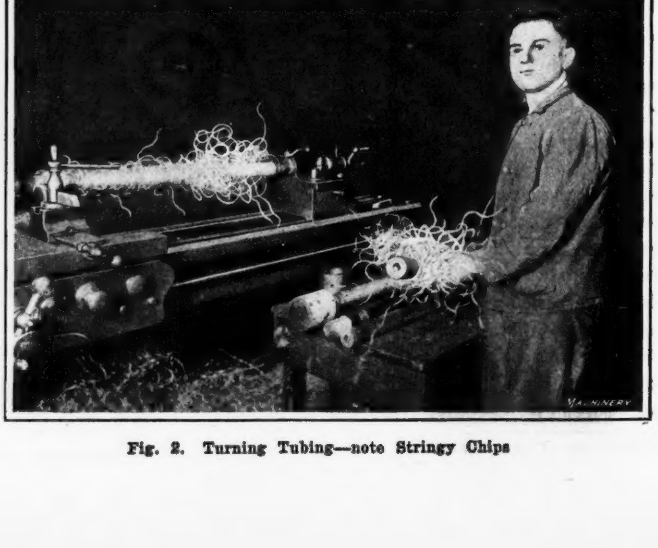


Fig. 2. Turning Tubing—note Stringy Chips

WORK-HOLDING FIXTURES FOR INTERNAL GRINDING

CHUCKS AND OTHER HOLDING DEVICES DEVELOPED BY THE HEALD MACHINE CO.

Many interesting devices have been developed for holding work for internal grinding, especially for holding gears and bushings. In the February number of Machinery several devices for holding gears and other classes of work were illustrated and described. In the following some additional chucks and devices developed by the Heald Machine Co., Worcester, Mass., will be reviewed.

Combination Collet and Adjustable Jaw Chuck

Fig. 1 shows a special chuck developed by the Heald Machine Co. for holding bushings, disks, gears, or similar work, which has a capacity ranging from 5/8 to 8 1/4 inches in diameter. The gripping of the work is accomplished by means of jaws *A* which are fastened by fillister-head screws to the three operating segments *B* of the collet chuck. The collet chuck is operated by a handwheel *C* attached to a tube that passes completely through the spindle of the machine and screws into the rear end of the collet. This operating mechanism is provided with a ball thrust bearing. In using this chuck, the jaws are adjusted to approximately the correct diameter and are then ground to run true. They are so designed that they can be reversed for holding smaller sizes of work down to 5/8 inch diameter. This chuck, on account of having the main collet made out of a single piece of alloy steel, will retain its accuracy longer than any chuck with which the manufacturers have had experience heretofore, while at the same time it has the ability to handle an extremely wide range of work.

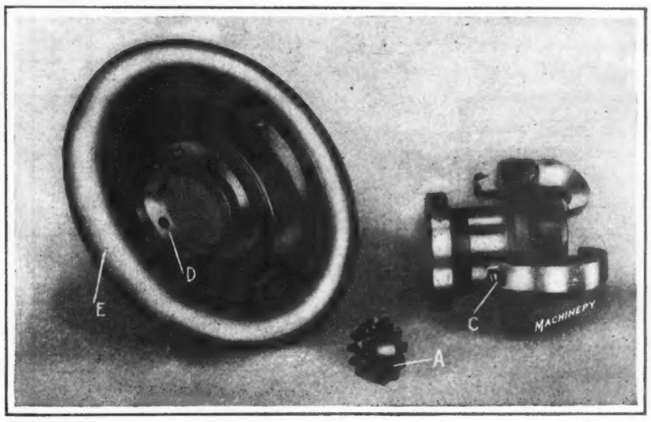


Fig. 3. Bevel Pinion Chuck shown in Fig. 2, dismantled to show Construction

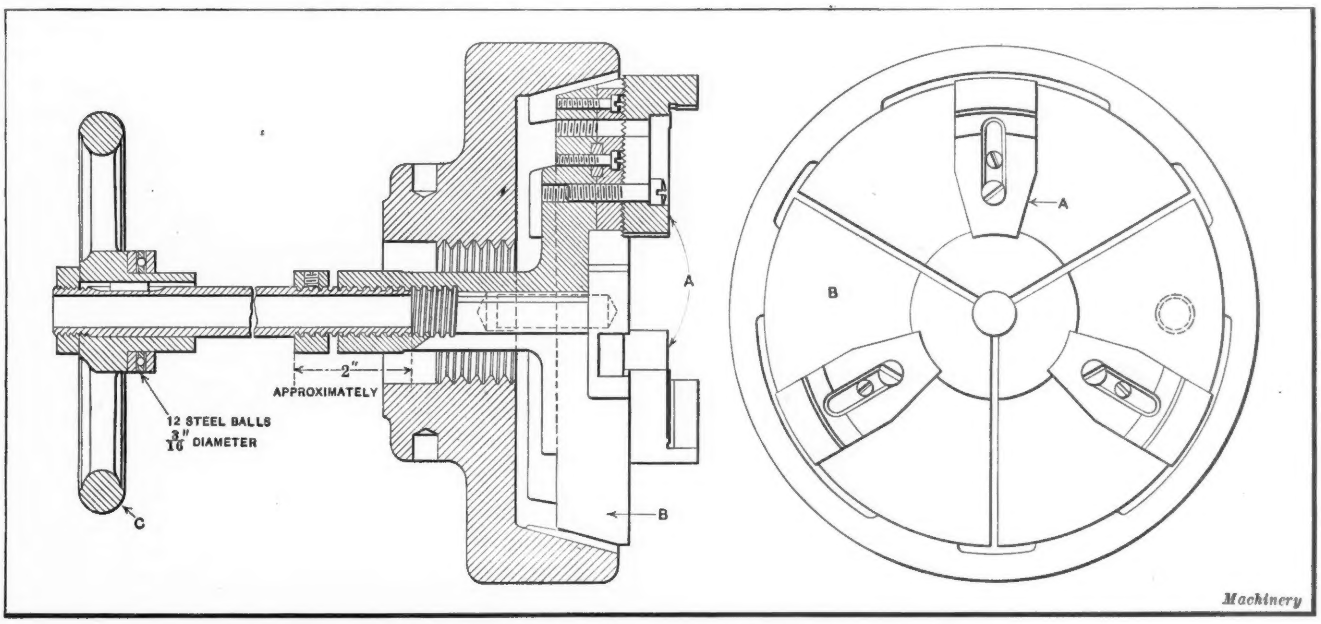


Fig. 1. Combination Collet and Adjustable Jaw Chuck for holding Bushings, Gears, etc.

Chuck for Holding Bevel Pinions

Figs. 2 and 3 illustrate an interesting chuck which is used for holding small bevel pinions. This chuck was designed by one of the largest automobile manufacturers in the country and uses three tapered rolls to true up the pinion, working from the pitch line. By referring to Fig. 3, which shows the fixture dismantled, a good idea can be obtained of its design and construction. The pinion, which is shown at *A*, is held in the chuck by means of three fingers that are provided with adjustable screws *C*, bearing on the three locking cams *D*. These three cams are mounted on a heavy handwheel *E*. This handwheel was made in these proportions with the idea that the starting and stopping of the work to a certain extent automatically clamped and released the work. The inertia of the wheel when starting tends to clamp the work tighter, and the tendency of the wheel to keep on turning when the work-spindle is stopped is likely to loosen the chuck, so that in actual operation the designer figured that the operator would be required to make almost no effort to clamp or release the work in the chuck. The most objectionable detail in regard to the construction is the amount the jaws project beyond the face of the work. With this particular pinion, having a short hole, it is not a serious matter,

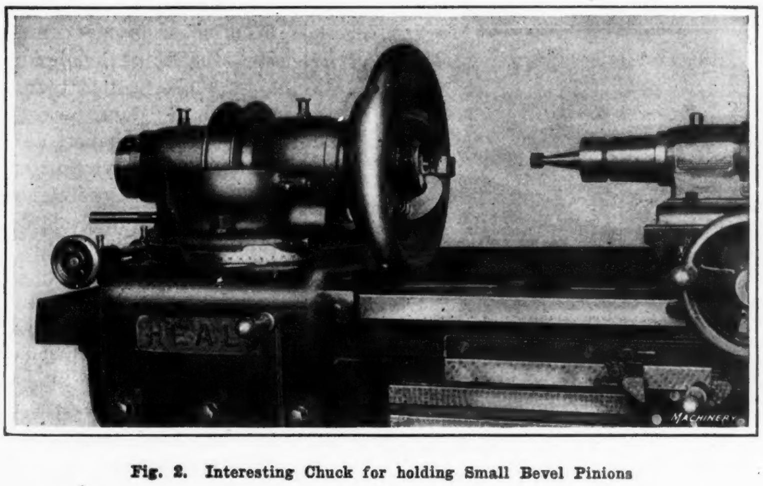


Fig. 2. Interesting Chuck for holding Small Bevel Pinions

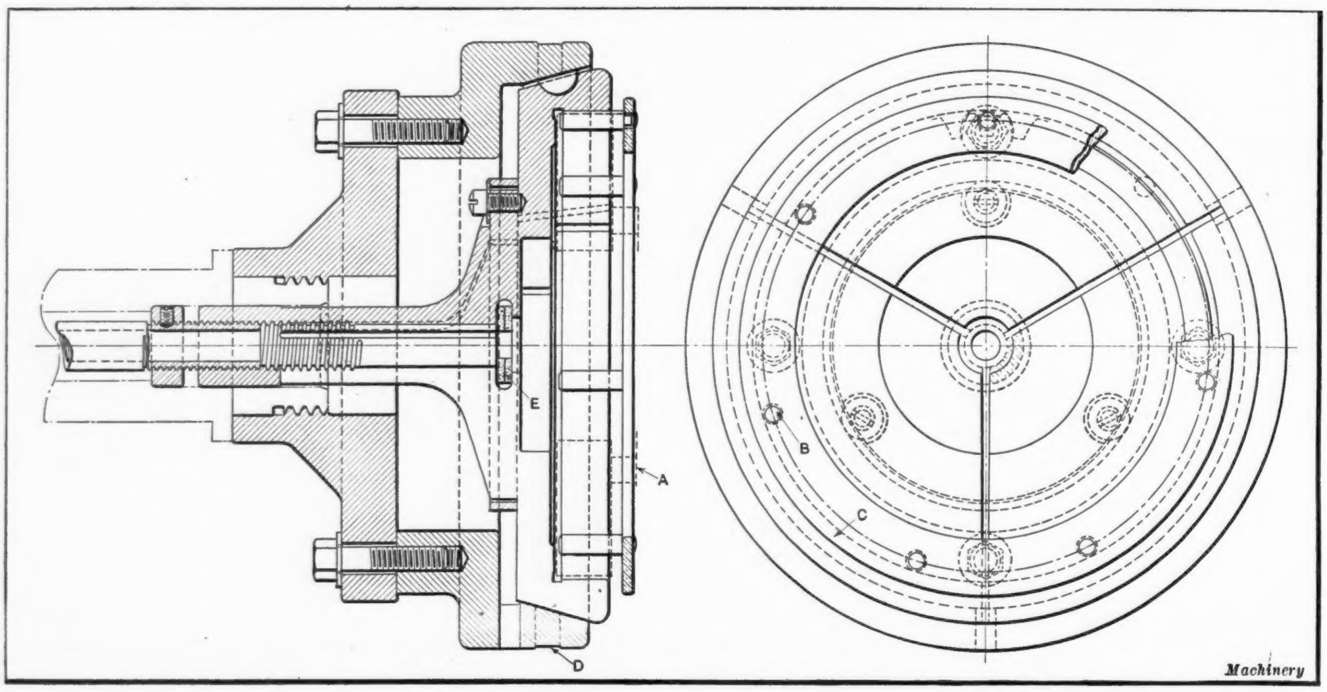


Fig. 4. Special Collet Chuck for holding Spur Gears

but it would take up valuable room and make it necessary to provide an unusually long grinding spindle if the work should happen to be of such a form that a relatively long hole was to be finished; this would necessitate using an extra long spindle to make up for the amount of space lost in this way.

Special Collet for Holding Spur Gears

In Figs. 4 and 5 is shown a special collet for holding spur gears. By referring to Fig. 4, it will be noticed that the gear *A* to be ground is held by seven pins or rolls *B*, bearing on the pitch circle of the teeth and carried in a retainer ring *C*, as illustrated. In fitting up the chuck, the opening in the collet is finished true by grinding, and then the outside is trued up by grinding at the point *D*. In operation, the gear, together with the rolls and retainer ring, are inserted in the opening in the chuck and the jaws closed sufficiently to hold the gear for grinding, which requires but a very light grip. This method of using rolls between the teeth gives pitch line control which seems to give in every case the best average setting for any gear to give smooth running qualities. If for any reason the chuck has to be removed from the machine and later replaced, its accuracy can be tested instantly by putting an indicator on the surface *D;* and if for any reason the collet has shifted so that it does not run true, it can be made to run true by loosening the large bolts in the rear and shifting it slightly on the faceplate until a true running position is obtained. The collet has a felt washer at *E* to prevent grinding dust from getting into the threaded portion where the collet is drawn in. The collet is closed and opened by a rod passing through the spindle of the machine and operated by a handwheel at the rear, similar to the arrangement shown in Fig. 1. This chuck can be provided with collets of various shapes for holding gears of various sizes, the collet for a smaller gear being shown at *A* in Fig. 5. D. T. H.

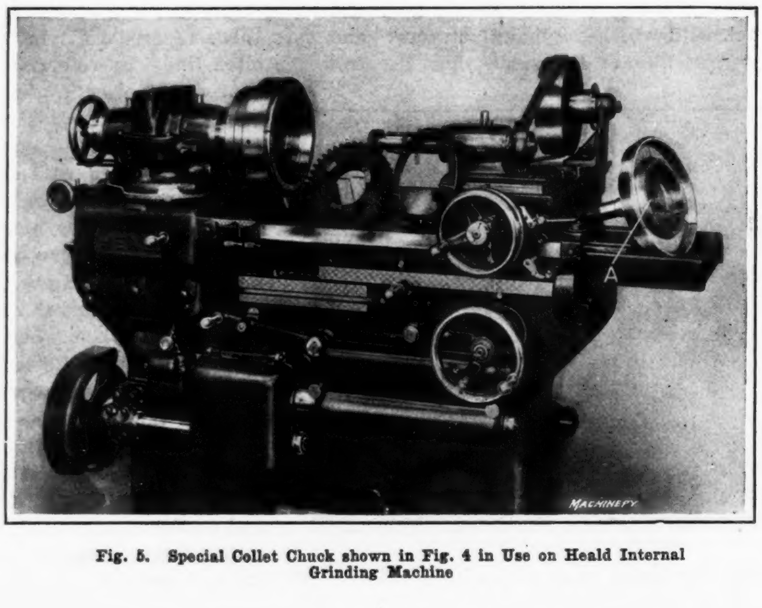


Fig. 5. Special Collet Chuck shown in Fig. 4 in Use on Heald Internal Grinding Machine

INCREASE IN COPPER OUTPUT

There has been a steady increase in the rate of copper output since early in 1915. The production during the latter half of 1915 considerably exceeded that of the first half according to a report of the United States Geological Survey. During the year the refineries produced from both domestic and foreign ores a total of 1,634,000,000 pounds of blister copper, of which 1,388,952,700 pounds was produced from ores mined in the United States. The average price for the copper has been higher than at any time in recent years, the average for the first six months of 1916 being more than twenty-six cents a pound. The cost has doubtless increased slightly, as the important copper companies have increased the wages of employes. Many small mines are operated that could not be profitably worked under normal conditions, and this, of course, tends to increase the average cost per pound.

* * *

Wooden roof trusses of unusual dimensions are being built in Europe according to a patented method known as "System Stephan." The wood is impregnated with a fireproofing impregnation; the roof construction is much lighter than one made from steel, and spans up to 200 feet have been constructed without any intermediate supports. The advantages claimed for this system of roof construction are that the covered area, being free from pillars and supports, can be used to better advantage, the illumination of the covered area can be arranged more advantageously, the impregnated wood is more fireproof than steel, and is not affected by dampness, acids, or acid gases, and, in addition, the construction is cheaper, and can be erected in a shorter time and with less elaborate hoisting apparatus than a steel construction. Up to the present time factory buildings, railway stations, and similar structures with a total floor area of 200 acres have been covered by these wooden roof trusses in northern Europe.

BETTER APPRENTICES

BY E. W. WRIGLEY*

Lately the scarcity of good mechanics has been causing considerable embarrassment to shop managers, and many ways have been devised to overcome it, but not enough attention has been given to the real cause of the trouble, namely, the failure of the managers themselves to keep up the supply by properly training apprentices. A first-class mechanic cannot be produced in a few months; it takes years, and the only way to keep up the number is to keep training the boys.

The increasing tendency toward specialization in modern shop practice has done much to cause managers to slight this department of their works. As long as mechanics were available, and especially if business were at all dull, they drifted along and gave scant attention to the boys supposed to be learning the trade. Now business is better and mechanics are at a premium—in some places they cannot be obtained at all—and business is suffering as a consequence.

The opportunities in the mechanical trades for an intelligent and properly trained man are as great as in any other line of work and greater than in many. The more education along general lines that he has had, the more easily he will be able to see and benefit by these opportunities. This fact seems to have escaped a great many, and it is quite rare these days to hear of a boy who has had a high school education starting in to learn the machinist trade. The majority of apprentices are boys who leave school as soon as the state laws permit, and if they ever reach the stage where they can calculate the thread cutting gears of a lathe, they have attained the height of their ambition.

The only remedy seems to be to start now what should have been started some time ago, and give more time and consideration to this branch of the industry. A few firms have a carefully worked out system of training their apprentices and find it profitable, but the majority give very little attention either to what is taught or to the class of boys that are hired. The boys are turned loose and drift around the shop in a haphazard way for the required four years, and if they turn out to be mechanics, it is because of a natural aptitude for the work and not because any attempt has been made to teach them. The result is that the apprentice system has fallen, to a certain extent, into disrepute among boys who are starting out to prepare themselves to earn a living. They are told that it is impossible to learn a trade thoroughly as an apprentice, and the better class seek an opportunity in some other line. This will have to be corrected if it is desired to keep up the supply of good mechanics.

This training of young mechanics need not necessarily be confined to the large manufacturing plants, but can be carried out in the smaller places as well. In fact, if conditions are as they should be, a small shop doing a general business is one of the best places for a boy to learn a trade. Here the right kind of boy will form acquaintances that will prove very valuable to him. As soon as the men understand that the management is making a serious attempt to get a better grade of apprentices and really intends to teach them something, they will do their share, not only in getting better boys to start, but also in helping them after they are started. Every mechanic who is any good has pride in his trade and thinks that it is just a little better than any other, and that he has to know a little more to hold his job than the other fellow. When he has been shown that a boy by starting as an apprentice will really be taught the trade, he will soon be inducing the desirable boy to start.

The writer well remembers when he started his apprenticeship. Being just from high school, he was older and larger than the other boys starting at the same time, and naturally was made the butt of some good-natured chaff. But it was not long before the older men saw that he really wanted to learn, and because of having been to school longer, could more easily grasp the things told him. After that it was much easier, for although there was little systematic training of apprentices in this shop, as in most shops at that time, he was taken in hand by some of the older men and taught the ins and outs of the work about as fast as he could learn them. At the end of his apprenticeship he was frankly told by the foreman that he could do better by leaving and seeking employment in some other shop, as they had a rule limiting the wage that could be paid a man for the first year after he had served his apprenticeship.

The introducing of new and better methods of handling the apprentice problem, and the attracting of a higher grade of boys, is a large and important phase of the manufacturing business today, and the way it develops will be watched by many.

* Address: 5633 Brooklyn Ave., Seattle, Wash.

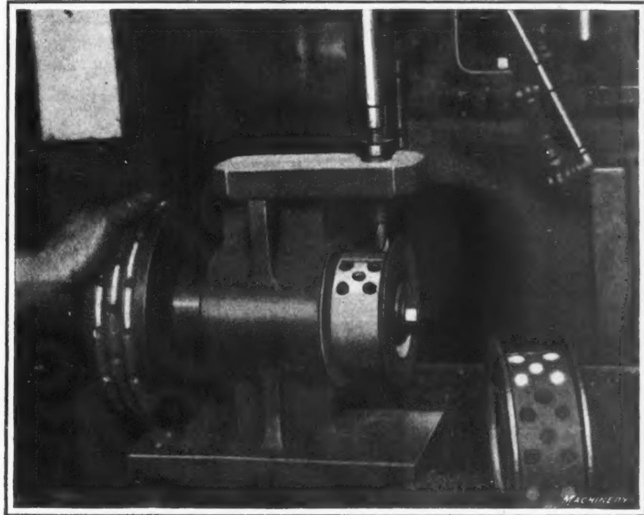
* * *

INDEXING DRILL JIG

The necessity for a drill jig of the indexing type was brought about by a certain design of flat-belt motorcycle drive pulley. This pulley is of the flat-belt, flanged type, having cork inserts over its entire periphery.

To the right in the accompanying illustration is shown a completed pulley with the cork inserts in place. Mounted on the drill jig is shown a pulley being drilled. The pulley is 4½ inches in diameter and has forty-two holes, ½ inch deep, arranged in three rows of fourteen equally spaced around the periphery. The drill jig is built in such a manner that it will take a large variety of sizes of pulleys.

At the left of the jig is shown a large drum which serves as a means of indexing the drill jig readily, and has three annular grooves on its periphery, spaced the same distance apart longitudinally as it is desired to have the holes drilled



Pulley Drill Jig in Operation

on the pulleys. Directly in the center of these grooves and spaced equidistantly around the periphery are fourteen tapered index pin holes. At the base of the drill jig is an index pin (not shown), which is tapered on the end to fit the tapered index hole. At the back of this index pin is a light spring which holds it constantly in contact with the index drum.

In operation, the first row of holes is drilled. When enough pressure is applied to the drum to rotate it, the index pin, being correctly tapered, will jump out and allow the drum to revolve to the next index hole. After the first row of holes has been drilled in this manner, the second row is placed in line with the revolving drill by forcibly sliding the index drum and its shaft longitudinally until the index pin jumps into the middle groove. In this position the fourteen central holes are drilled as before. To drill the last row of holes it is only necessary to move the index drum over as in the second case.

For drill jigs where it is essential to drill holes accurately spaced around the periphery, this form of index drum and pin might not be accurate enough. However, in this case and in many other cases it is sufficiently accurate. It has the advantage of being quickly indexed, which is not always true of the ordinary index pin that has to be grasped by one hand while the other hand is employed in rotating the fixture. In this case, the right hand is never moved from the drill spindle lever.

V. B.

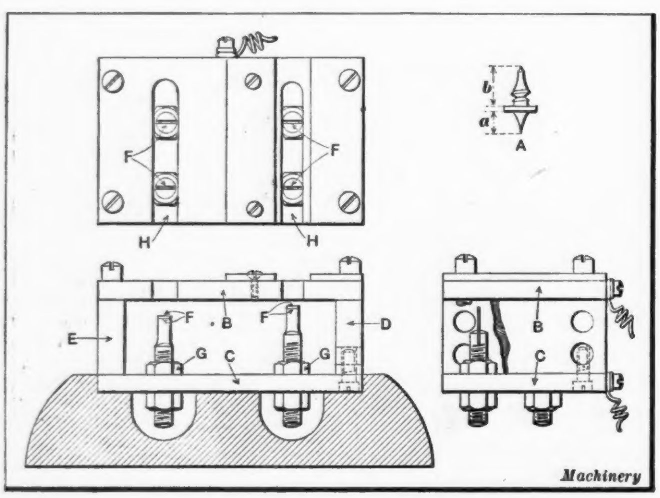
LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

ELECTRICAL LIMIT GAGE

The following describes an interesting electrical limit gage for testing time fuse firing pins of the form shown at *A* in the accompanying illustration. The dimensions *a* and *b* have to be tested for accuracy, and it was for this purpose that the electrical limit gage was designed. It will be seen that the gage consists of top and bottom plates *B* and *C*; plate *B* is made of tool steel, hardened and ground, while plate *C* is made of machine steel and left soft. These two plates are fastened together by fillister-head screws and special nuts, which enter the fiber side pieces *D* and *E*. The fiber is used because it is a non-conductor and thus provides for insulating the top and bottom plates from each other.

This gage is of the "go" and "not go" type, and its operation depends upon having the work to be tested close the electrical circuit between the plates, which causes a telegraph sounder to click. Four contact points *F* made of spring steel are soldered into the heads of screws which provide for adjusting the height of the contacts. Lock-nuts *G* are for adjusting the contact points to the proper height and locking them in position.



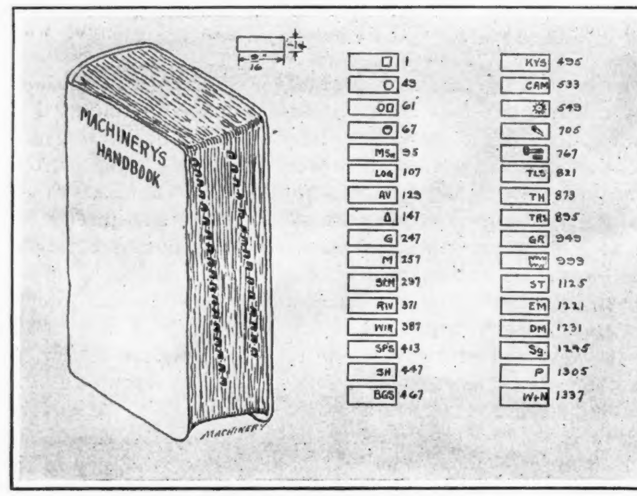
Electrical Limit Gage for testing Time Fuse Firing Pins

In using the gage, the firing pins to be tested are placed in the front end of slots *H* and pushed forward over the contact points *F*. If the firing pin touches either of the points it completes the circuit and the sounder clicks. The first contact point is adjusted to such a height that if the tip of the firing pin touches it, it shows the work is too long; similarly, if the pin does not touch the second contact point, it is too short. In either case the work will be rejected. It will of course be evident that one of the slots *H* provides for testing dimension *a*, while the other slot is used for testing dimension *b*. It is a very easy matter to keep this gage accurately adjusted.

DONALD BAKER

THUMB INDEX FOR MACHINERY'S HANDBOOK

In the June number of MACHINERY an abbreviated index for MACHINERY'S HANDBOOK was published, which made me think that I would like to pass along the method I have used for a thumb index on my handbook with success. The accompanying illustration shows the general scheme employed and the abbreviations which were used on the writer's index tabs. These index tabs can be altered to suit individual needs, depending upon the class of work on which the user is engaged. A chamois skin was purchased at a drug store and pieces 9/16 by 1/4 inch were cut out of the smoothest part by using a cardboard templet, after which they were lettered as shown with black India ink, by spotting the ink on with little dots instead of in the usual way; they were then pasted on the right-hand pages of the handbook. Photo paste was used on the chamois skin very sparingly and the tab pressed firmly on the page until it adhered.



Method of indexing Handbook

By holding the back of the book in the left hand and placing the right thumb on the index tab, references can be made very quickly. The writer has three reference books that he has indexed in this way, and has found the method convenient and readily applicable with comparatively small expense and little trouble.

Lyndonville, Vt. EARL W. PETERSON

ETCHING GRADUATIONS ON GAGES

In the September, 1915, number of MACHINERY, in an article entitled "Snapshots On the Road," I noticed a short description of a method of etching nameplates; and this suggested the means of overcoming difficulty which we had experienced in graduating gages of the form shown in the accompanying illustrations. These gages were made of ½-inch drill rod, and the largest diameter was 0.490 inch. There were four lines to be marked on each gage, and it was decided to grind the graduations in the hardened gages. But when an attempt was made to handle the work in this way, it was found that the wheel would not hold a sharp edge, with the result that very poor lines were obtained. As the limit of accuracy required on this work was ± 0.0002 inch, this method was obviously unsatisfactory, and we were in search of a more efficient way of doing the work when I happened to see the article referred to.

As a result, we decided to try etching; a thin coat of wax was spread over each gage, after which it was mounted on

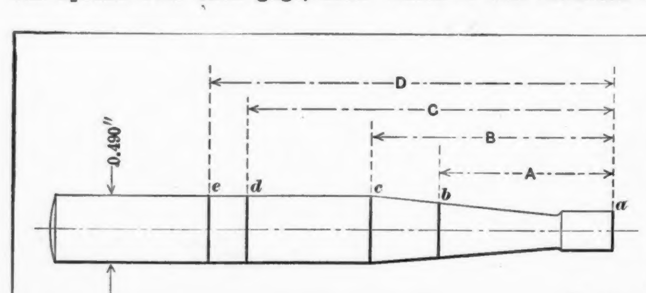


Fig. 1. Gage to be made showing Graduations at b, c, d and e

centers on the milling machine. The marker held in a fly-cutter shank, as shown in Fig. 2, had its point brought to coincide with end *a* of the gage, and it was then a simple matter to move the table through the required distance *A*, Fig. 1, to locate the marker for making the first line *b*. Then the table was moved successively through distances *A*, *B*, *C* and *D* in order to locate the marker in the proper positions for graduating lines *b*, *c*, *d* and *e*. It will be obvious that to

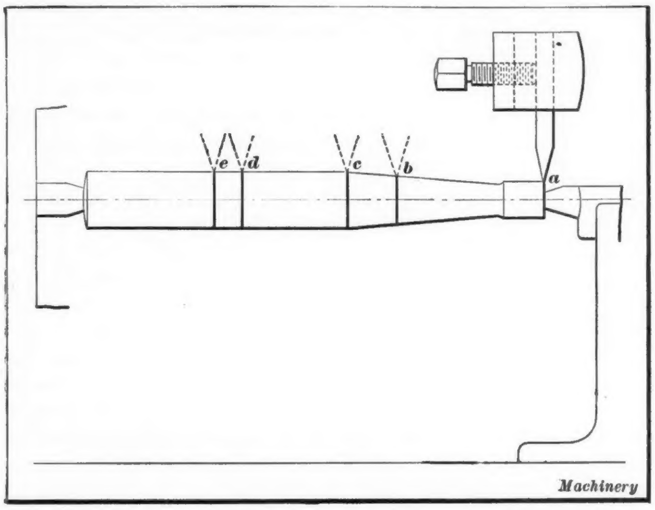


Fig. 2. Method of cutting Graduations in Wax preparatory to etching

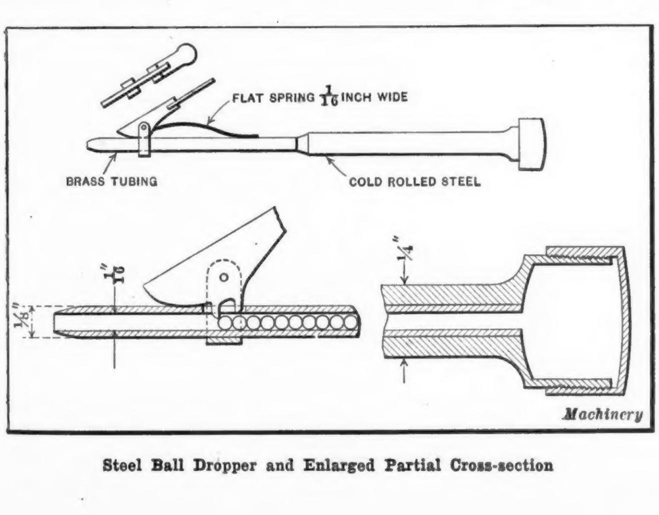
graduate each line in the wax, it was merely necessary to bring the pointer into contact with the work and then rotate the work through one complete revolution. A mixture of one part of nitric acid and one part of water was then applied and allowed to "work" for three or four minutes, after which the acid was thoroughly washed off with water and the wax removed from the work. The micrometer graduations on the screw of the milling machine enabled the lines to be spaced with the required degree of accuracy.

Bridgeport, Conn. CARL GOTTHARDT

STEEL BALL DROPPER

A steel ball 1/16 inch in diameter is not an easy thing to handle, even with the aid of a suitable pair of tweezers. Such a diminutive sphere, when removed from its fellows in the bearing, seems to become animated and determined to shoot through space without the impetus afforded by an explosion; and to avoid loss of time and balls occasioned by dropping and losing them in attempting to replace the balls in the race groove, we designed the ball dropper shown in the accompanying illustration, which proved to be a very useful tool in the shop.

The trigger and spring are made of tool steel which was hardened and drawn to a blue color; the upper end and screw cap were turned from a piece of ½-inch round brass stock. The chute was made of a piece of 1/16-inch brass tubing which was sweated into the upper end of the ball reservoir; and the yoke for holding the trigger, pin and spring was



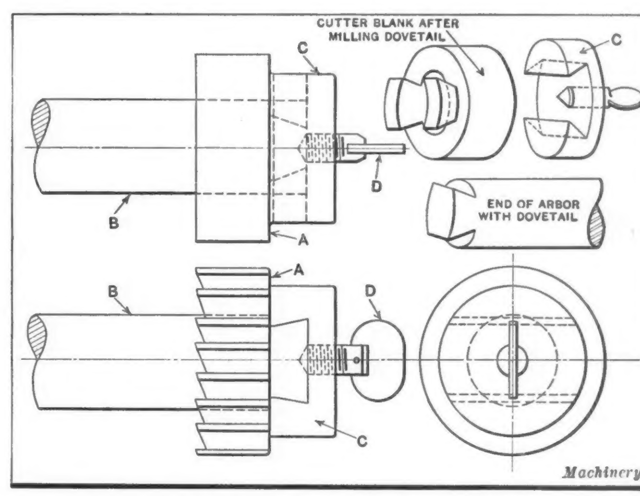
Steel Ball Dropper and Enlarged Partial Cross-section

soldered in place. Then all brass parts were nickel plated to improve the appearance of the tool. At the outlet from the ball reservoir, the corners of the brass tube were first made with a slight chamfer, but this allowed the balls to become jammed at the entrance to the tube so that they would not flow freely; we faced off the end of the tube to give a sharp corner, and after this no difficulty was experienced. It will be evident from the illustration that only one ball can be released at a time, a ball being dropped each time the trigger is pressed down.

Bayonne, N. J. WILLIAM A. HAWES

DRIVE FOR BACK COUNTERBORE

A very satisfactory way of driving back counterbores, back face mills and similar tools is shown in the accompanying illustration. This device is used where the cutter must be secured to the end of the arbor after the arbor has been passed through the hole. Cutter *A*, which is a sliding fit on arbor *B*, is turned down on the back end to a diameter just below the bottom of the flutes, and a dovetail is milled across each side. This dovetail is cut so as to register with a similar dovetail milled on the extension of the arbor. When the cutter and arbor are assembled, the complete dovetail is such as to fit the mate in cap *C*; and tightening the thumb-screw *D* holds



Arrangement of Drive for Back Counterbore or Back Face Mill

this cap in place. Thus the cap forms a driving coupling between the arbor and cutter which may be quickly slipped on and off.

Bridgeport, Conn. W. BURR BENNETT

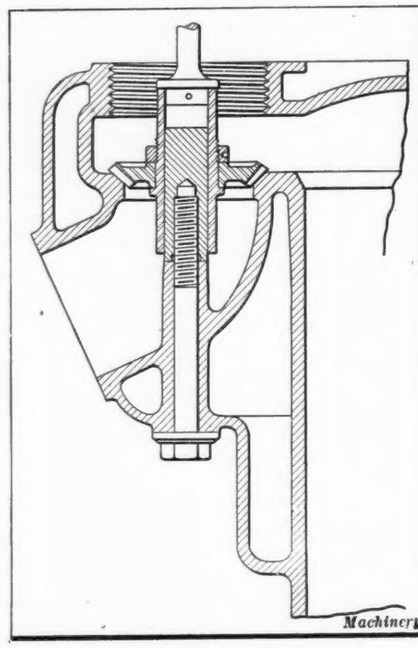
FITTING TAPERS

In fitting taper parts, such as lathe centers, miller arbors, etc., it is customary to rub chalk, Prussian blue or red lead on them before trying them together, so that the high spots will show bright after the parts have been wrung together. While chalk will answer the purpose on rough work, the other two are to be preferred for finer work, but as they are rather mussy and inconvenient, it may be of interest to learn that there is a blue pencil on the market used for marking on glass, china, metal, etc. This is much more convenient to use or to carry, either in the pocket or the tool kit, and it will give practically the same results as Prussian blue, while the marks made with it leave just the right amount of blue on the work without smearing or waste. The pencils I have were made by the Faber Co., and as they are a German product, it may be difficult to obtain them at present, although they are usually kept by stationery and art supply stores. D. B.

RESEATING GASOLINE MOTOR VALVES

The illustration presented in connection with the following description shows a gasoline motor valve seating tool which has been found to give very satisfactory results. I have never found the method of assembling the reamer directly on a 5/16 or 3/8 inch diameter stem to give sufficient rigidity to

insure obtaining a valve seat concentric or true with the valve stem hole in the guide; and I have often ground valves in which this method was entirely useless on account of poor hand reaming. Valves can be given a true seat in a very short time and with very little grinding if the seats are carefully reamed at the start; and an advantage of the tool shown in the accompanying illustration is that the cutter revolves around a large bearing surface which is located exactly at the center of the circle being reamed.



Efficient Type of Valve Seat Reaming Tool

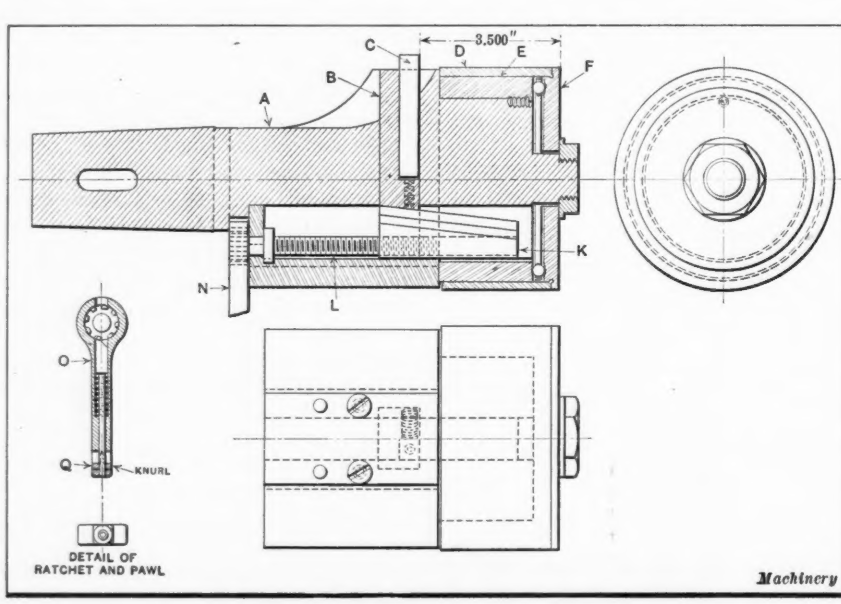
It will be seen that the cutter is mounted on a piece of steel tubing which is turned down to a shoulder and threaded to receive a nut for clamping the cutter in position, after being carefully reamed to give the tube a smooth concentric hole. The plug on which the tube turns can be made of a piece of good close-grained cast iron, and after being drilled and tapped, a hole should be drilled to a depth of about 1/8 inch, using a drill 1/32 or 1/16 inch larger than the tap size; then the end of the plug is faced off true, and it also ought to be ground to size on the outside. The form of clamping screw used in the guide and the method of mounting are so clearly shown that no description is required. Any suitable stem may be placed in the top of the tube to accommodate the form of drive which is to be used. If this joint is very loose and simply held with a large cotter-pin, very good results will be obtained, as the tool will be given more or less float and thus be able to center itself readily. Obviously, it is necessary to first spot-face the ends of the valve stem guides just enough to break away the scale and provide an accurate surface for the bearing plug to rest on.

Los Angeles, Cal. H. W. RICKS

RECESSING TOOL FOR HORIZONTAL BORING MILL

The tool shown in the accompanying illustration was designed for cutting a recess in the worm-gear bearing in a steel casting, the machine on which the work is done being a horizontal boring mill. The recess is used to locate and hold a thrust washer, and the requirements of the work are that the groove must be accurate in its width and correctly located from a shoulder 3½ inches distant.

Referring to the accompanying illustration, the body of the tool *A* is made of machine steel, and the shank is held in the end of the spindle bar by a draw-in slot and wedge. The tool-holder block *B* carries the tool *C*. The block is operated by wedge *K*, controlled by screw *L* through ratchet handle *N*. The diameter of the hole in which the recess is to be cut is 0.004 inch larger than the hardened bushing *D*, and the location is insured at the beginning of the operation by carrying the tool into the bored hole until the thrust washer *F* comes against the shoulder mentioned, being held in this position by pressure on the handwheel which controls the longitudinal movement of the spindle. As the machine spindle revolves, the friction is relieved by the ball bearing shown, the outer bushing remaining stationary and also serving as a pilot for the holder. At each revolution of the spindle, the handle *N* is given a partial turn by means of a knocker fastened to the table, and as the spindle continues to revolve, the handle returns to its original position by the action of gravity, the ratchet pawl *O* slipping past the teeth on the ratchet as indicated.



Recessing Tool for Horizontal Boring Mill

The depth of the cut is gaged by the end of the tool-holder block which is visible, and the chips drop out of the way through the cut which can be seen at the rear of the tool and holder. When the proper depth has been reached, the tool is withdrawn by reversing the ratchet pawl in the handle by means of the knurled portion *Q*. This method is somewhat slow, but is not at all complicated and the withdrawal can be accomplished in a short time. The bushing *E* is of hardened steel and is pressed onto the body to take the wear from the side pressure caused by the cutting action. Its use also prevents the hole in the casting from being scored. Prior to the use of the recessing tool, a roughing cutter is used to relieve the work, so that there is less metal to remove in the finishing cut and greater accuracy is insured. There is also less wear and tear on the tool itself, so that the maintenance cost is reduced to a minimum. The illustration will make the general points in construction perfectly clear and the method of operation readily understood.

Columbus, Ohio. OTTO R. WINTER

MILLING DOUBLE-ANGLE CLUTCH TEETH

On page 190 of Franklin D. Jones' book entitled "Planing and Milling," there is a formula for determining the angle a to which the axis of a clutch blank should be inclined while milling the teeth. This formula is perfectly accurate, but I find it more convenient to use when reduced to the following form:

$$\cos a = \tan \frac{180 \text{ degrees}}{N} \times \cot \text{ cutter angle} \qquad (1)$$

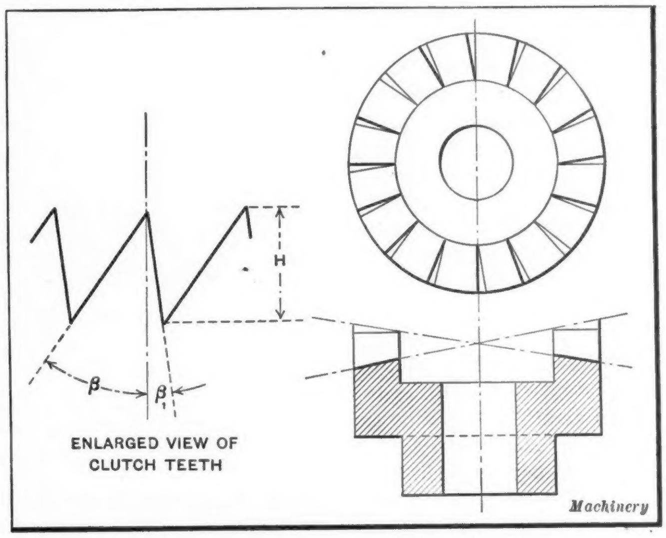
I have to mill a number of clutches for use on a certain machine, but they differ from the type referred to by Mr. Jones in that the teeth have a "double" angle as indicated in the accompanying illustration. Clutches with teeth designed in this way disengage more readily. In finding by calculation the angle a at which the clutch blank must be set for milling, the following equation is used:

$$\tan \beta \times \tan \beta_1 \times \cos^2 a + (\tan \beta + \tan \beta_1) \times \cot \frac{180 \text{ degrees}}{N} \times \cos a - 1 = 0 \qquad (2)$$

Reference to Formula (2) in connection with Fig. 1 will make it evident that

for a case where $\beta_1 = 0$, the clutch is of the type referred to by Mr. Jones, and for such a case Formula (2) reduces to the form given in Formula (1).

In designing these clutches I generally make angle $\beta = 55$ degrees, and angle $\beta_1 = 5$ degrees, and for these angles the values given in the accompanying table have been calculated. It will be seen that both the angle a and the value of cos a are given in the table, the latter being for the purpose of determining the drop of the cutter into the clutch blank at the rim. This value is indicated by H in the illustration, and has the following value:



Form of Double-angle Clutch Teeth, and Method of milling to insure Easy Engagement

$$H = D \cos a$$

where D = diameter of clutch blank.

After the teeth have been cut, the sharp edges are faced off in the manner indicated, which leaves little triangular surfaces for the opposing teeth to rest on momentarily while the clutch is being closed in case the teeth happen to come point to point at the instant of engagement. If the points of the teeth are left sharp and the clutch engages in this way, it is found that the teeth do not slide easily on each other, so that the engagement of the clutch is made rather difficult.

Bridgeport, Conn. D. Petri-Palmedo

COMMON CAUSE OF HIGH ELECTRIC POWER BILLS

Unsatisfactory power bills are not always the fault of the central station, neither are they always the fault of the consumer; but excessively high bills are sometimes the result of an unfortunate purchase of motors. While occurrences similar to the one here related are frequent, the following is probably the worst case that ever came to my attention. A consumer complained to the electric company about his bills and added the threat that if nothing could be done in the matter, he would be forced to abandon central station service and resort to the use of a gas engine for his power. Natural gas sold for thirty cents per thousand cubic feet, and the electric company knew from past experience that this was not idle talk on the part of the consumer.

The complaint was handed over to a solicitor with orders to investigate. The solicitor called, as directed, and the consumer produced his bills for the preceding year with the remark, "No matter how good or how slack business may be, I always get the same old bill for $40." The plant was an architectural iron works, *i. e.*, the company purchased I-beams, channels, angles, etc., drilled and cut them into such lengths as were required, and then erected the structural steel part of buildings. An examination of the bills showed that the statement of the consumer in regard to their amount was essentially correct.

At the suggestion of the solicitor, they went into the shop; and an inspection disclosed the fact that one fifteen-horsepower motor of standard make, more or less successfully rewound, was used for driving the whole plant. The solicitor asked the consumer to wait until the next day, so that he could conduct a test. This test was made as follows: The main belt was removed and the kilowatt input was observed when the motor was running free. The belt was then replaced and the power necessary to drive the motor and shafting was noted. The machines were then successively thrown on (loaded when convenient) and readings taken of the power drawn from the line. The following are the results of the test:

Motor running free (main belt removed), input..3.50 kilowatts
Motor plus lineshafting and loose pulleys, input..3.90
The same, plus small blower, input..............4.00
Last condition, plus Alstatter Shear accelerating, input..4.20
Last condition with shear running, plus Bliss punch accelerating, input....................4.10
Last condition with Bliss punch running and emery grinder working, input..............4.35

The last figure, namely, 4.35 kilowatts, represented what the customer called about average operation, and when multiplied by 240, which was the number of working hours per month, came surprisingly near to his average monthly consumption. One of the most remarkable things about this installation was that for about one hour and a half each day, immediately after the dinner hour, the fifteen-horsepower motor was operated to drive a small forge blower, for which a one-fourth-horsepower motor would have supplied ample power. The matter was laid before the customer, and the fact that he was paying about 80 per cent of his money to turn the motor and about 20 per cent for the energy which he required for producing his product was plainly shown to him. It was explained that while he could not escape paying something to turn a motor, that by trading in his fifteen-horsepower motor and with a slight additional investment he could equip his plant with small motors and reduce his power bill sufficiently to pay well for his added investment.

I could relate details of tests made on numerous other installations because of similar complaints. One of these was at an amusement park, where they were using a four-kilowatt belt-connected motor-generator set to supply current to a maximum connected load of less than one kilowatt in miniature lamps, and an average load of about one-fourth of a kilowatt; they were paying about $35 a month and got the benefit of about $3 or $4 worth of electricity. In another case a shop was operating a little one-half-horsepower forge blower with a five-horsepower second-hand motor; the proprietor picked up the motor cheap, and it ran the blower all right. I have seen so many of these instances that when a complaint of this kind comes in I take a wattmeter along and manage to see the consumer about noon, when the factory is shut down, so as to take his no-load motor input.

A. G. Drury

Cincinnati, Ohio.

VALUES OF a AND COS a FOR DIFFERENT NUMBERS N OF CLUTCH TEETH

N	4	5	6	8	9	10	12	15	16
Angle a in Degrees and Minutes	51 10	62 10	68 5	74	76 10	77 40	79 20	82	82 30
Cos a	0.6271	0.4669	0.3733	0.2756	0.2391	0.2136	0.1851	0.1392	0.1305

N	18	20	24	25	28	30	32	36
a, Degrees and Minutes	83 30	84	85	85 15	85 40	86	86 15	86 45
Cos a	0.1132	0.1045	0.0872	0.0828	0.0756	0.0698	0.0654	0.0567

Machinery

METHODS OF CHECKING MULTIPLICATION

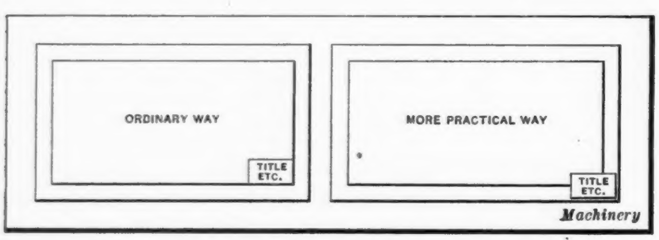
On page 700 of MACHINERY for April, 1916, under the heading "Methods of Checking Multiplication," it will be found that the process mentioned does not give quite correct results in all cases. The following method, which is taught in nearly all English elementary schools in India, is the quickest way of proving multiplication, and it will be found that it is absolutely correct in every case.

Example.—Multiply 84,689 by $5214 = 441{,}568{,}446$. Add all the digits of the multiplicand till one digit is obtained, thus: $8 + 4 + 6 + 8 + 9 = 35 = 3 + 5 = 8$. Do likewise with the multiplier, thus: $5 + 2 + 1 + 4 = 12 = 1 + 2 = 3$. Multiply the two results and add the digits till one digit is obtained: $8 \times 3 = 24 = 2 + 4 = 6$. Lastly, add the digits of the product till one digit is obtained, thus: $4 + 4 + 1 + 5 + 6 + 8 + 4 + 4 + 6 = 42 = 4 + 2 = 6$, and if the the result agrees with the result obtained by adding the digits of the preceding multiplication, the product is correct. We get 6 in both cases. Hence the product is correct.

Calcutta, India. J. R. ACKOY

ARRANGEMENT OF BORDER LINES AND TITLE

It is my purpose to describe what I have found to be a very practical arrangement in laying out the border lines and title frame on drawings; this is often the means of saving space which may be required for showing certain views of one or more small parts, and avoids the necessity of making separate detail drawings. The paper is cut around the edge about ⅛ inch from the outside border line, and experience has shown that it pays to have plenty of room between the



Comparison of Arrangements of Border Lines and Title

outside and inside border lines; we use a space of 1 inch on our standard drawings. This prevents the blueprints from becoming badly finger marked along the edges and avoids loss of time through mechanics having to go to the foremen or draftsman for further information in regard to an operation on which they are engaged. DRAFTSMAN

LINK FOR LIFTING DRIVING BOXES

The device shown in the illustrations for lifting driving boxes on and off machines has been found a very satisfactory means for the purpose in the shops of a large eastern railroad. The link is made of ¾ inch square wrought iron, bent to form the large loop and a ring at the top, and welded together. Two of the rings are used in lifting a box, as seen in Fig. 2. The links are made to suit the length of driving box, and a ⅜-inch endless chain holds the two links together. The chain is made of the proper length to allow the device

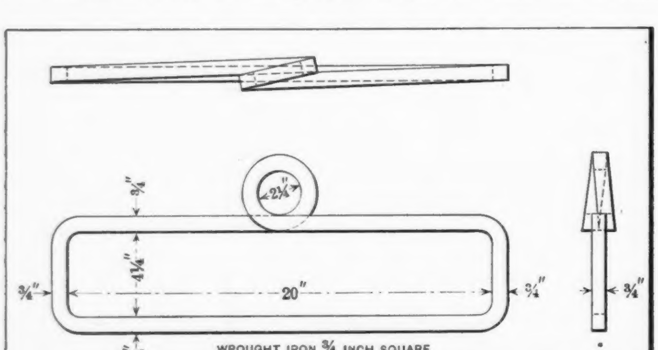


Fig. 1. Link for lifting Driving Boxes

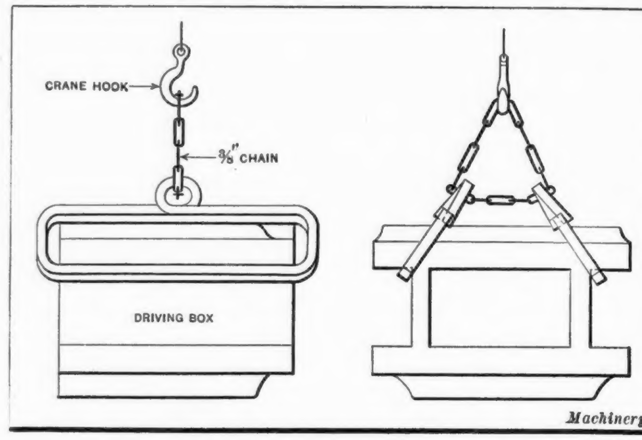
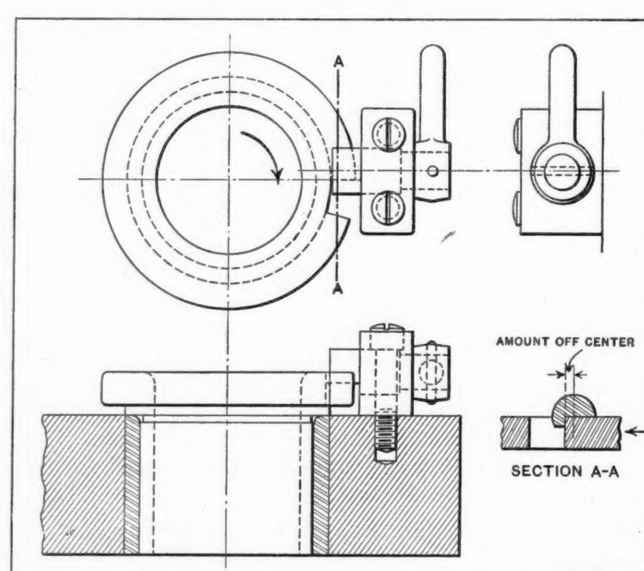


Fig. 2. Application of Pair of Links to Driving Box

to be quickly put on the box to be lifted and to adjust itself at about the angle shown when the box is being lifted. It is impossible for the links to slip in use, and there is nothing about the device to get out of order. L. K.

LOCK FOR SLIP BUSHINGS

It is considered good practice to use some sort of lock to prevent slip bushings from rotating and creeping up on the drill or reamer. This lock should be fool-proof, of few parts, and sturdy enough to withstand shop abuse. The accompanying illustration shows a lock which amply fulfills the above requirements and can be used for locking eccentric bushings. It consists of a pin milled out on the end, supported in a bearing, and having a lever pinned to the other end. The milled end of the pin when in position (as shown in section A–A) keeps the bushing from rotating and creeping upward. The shoulder which the edge of the bushing strikes is off center of the pin; this tends to rotate the pin as the bushing tries to turn from drill friction, thus locking it tighter. In the



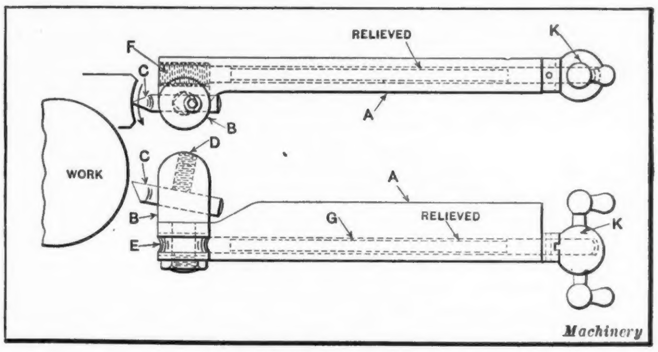
Lock for Slip Bushings

illustration, the bushing is shown as tending to turn clockwise, which would be the condition when using a right-hand drill. By lifting the lever to an upright position the bushing can be withdrawn vertically.

Bridgeport, Conn. W. BURR BENNETT

ADJUSTABLE RADIUS LATHE TOOL

The accompanying illustration shows an adjustable radius lathe tool made by the writer. The tool-holder *B* is ground true so that measurements can be easily taken from it to set the tool to any radius within its capacity. The body of the holder *A* is made from cold-rolled steel which is finished to size and casehardened. The end of the holder carrying the



Adjustable Radius Lathe Tool

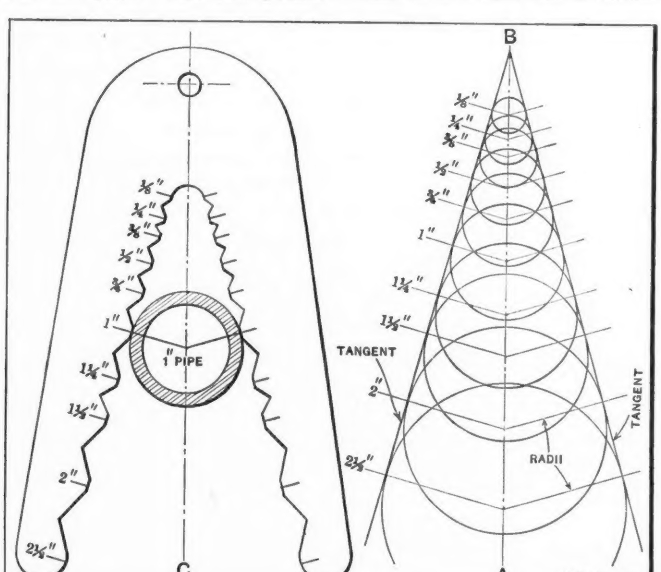
radius tool is formed as shown and is provided with the holder mentioned in which the tool *C* is secured by means of the set-screw *D*. The worm-wheel *E* is slipped onto the squared-up portion of the tool-holder *B*, and meshes with the worm at the end of the operating shaft *G*, the movement of which is controlled by the handle *K*. This handle can be readily removed so that the tool body *A* can be slipped into the holder on a lathe carriage. The worm is ⅜ by 16 inch and the shaft is relieved in the middle portion so that it obtains a bearing only on each end; that is, near the handle and near the screw. The tool shown has been in use in the tool-room for the past six months and has given complete satisfaction.

Kenosha, Wis. H. E. ANDERSON

CONVENIENT PIPE GAGE

I have often found, when called upon to measure up old pipe work, that considerable time is lost, especially when a number of various sized pipes are involved. The accompanying illustration shows a very convenient form of pipe gage which the writer has had made and which he has found to be a great help whenever pipe sizes of any kind are to be taken.

The following method will be found convenient for laying out the gage. The two points *A* and *B* are laid out 3 inches



Convenient Pipe Gage

apart on a common center line, using a piece of 1/16-inch brass or copper sheet and scribing the line carefully upon it. With the points *A* and *B* as centers, describe two circles, respectively, 2.87 inches and 0.4 inch in diameter. These circles represent the outside diameters of the 2½-inch and ⅛-inch standard pipe sizes. Tangents should then be drawn to each circle, as shown, and other circles laid out on the center line, using the table of pipe sizes given herewith as a guide for the diameters. Each circle must have its circumference in the tangent, as shown in the diagram. Radii are now drawn in each circle perpendicular to the tangent, which gives the location of the various points of tangency. These points will be the points of contact for pipes of similar size placed in the gage. After all the lines have been located, an outline can be shaped for the gage similar to that shown at *C* in the illustration. After this, the material can be cut out with a hacksaw and file and the different pipe sizes can be stamped at their proper locations with steel dies. It will be found advisable to cut notches between the measuring or contact points with a file so that the pipe size can be determined easily even when operating in a dark location. If desired, the finish of the tool can be improved by polishing and nickel-plating. The gage will give any pipe size accurately from ⅛ inch to 2½ inches diameter. The size of the gage is convenient and it will readily slip into the pocket.

STANDARD IRON PIPE SIZES

Nominal Size, Inches	Actual Outside Diameter, Inches	Nominal Size, Inches	Actual Outside Diameter, Inches	Nominal Size, Inches	Actual Outside Diameter, Inches
⅛	0.40	¾	1.05	2	2.37
¼	0.54	1	1.31	2½	2.87
⅜	0.67	1¼	1.66	...	....
½	0.84	1½	1.90	...	....

Machinery

Irvington, Baltimore, Md. B. FRANCIS DASHIELL

VALUE OF LOGARITHMS TO THE TOOLMAKER

The advice which Mr. Jacobs, in MACHINERY for July, gives to the ambitious toolmaker is very interesting to me, as it must be, I think, to all of us who have traveled the path he there maps out. I should like to add a bit of advice to the machinist whose ambition goes one step farther—who wishes to get a thorough knowledge of all the trigonometry that will be of use in his work, and is not content with the ability to deal with right-angled triangles. This advice is that, before he undertakes trigonometry, he should thoroughly master logarithms. I have had the pleasure of assisting many machinists to acquire a practical working knowledge of trigonometry, and have invariably found that those who can handle logarithms in an efficient, workmanlike manner make far more rapid progress and with much less wearisome labor than those who lack this simple accomplishment.

It is no light task for a man, after his day's work in the shop, to sit down in the "College of the Midnight Lamp" to a lot of problems which perhaps involve multiplication by two or three trigonometric functions and division of the product by one or two more. One who is of mature age, and whose school days are far in the past, is likely to find the arithmetical labor wearisome and to feel that, though he may be refreshing his grammar-school knowledge, he is making but slow advancement in trigonometry. It is not surprising that many such students grow discouraged.

If, however, one first learns to use logarithms with the same facility as one's shop tools, the study of trigonometry presents a wholly different aspect, for the drudgery is eliminated. Any number of multiplications and divisions can be performed simultaneously by a single addition of logarithms, and the extraction of square, cube or any other roots is a mere matter of short division. Incidentally, the use of logarithms tends to greater accuracy, as it removes the ever-present temptation to omit, in calculations, all but two or three places of decimals. I know that some yield, in this matter, to the lure of the easy way, for I have checked up many a jig drawing some of whose dimensions were several ten-thousandths off, because the man who figured them had used only two- or three-place functions in order to lessen his arithmetical toil.

Even if it were difficult to get a working familiarity with logarithms, the time and labor required would be well spent, but it is a very easy matter. One of MACHINERY's twenty-five cent reference books, No. 53, will give all the essential information, and if help is needed to get one over a hard place, it can be readily obtained, for every student, it seems to me, must have within reach someone who has been up against the same difficulty, and who will gladly explain the matter.

New London, N. H. GUY H. GARDNER

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

"EFFECTIVE DIAMETER" OF SCREW THREADS

J. L.—What does the term "effective diameter" mean applied to screw threads? Is it the diameter of the screw at the root of the thread?

A.—The term "effective diameter" means the "mean diameter" or "pitch diameter," as it is generally called in America. The term is of British origin and its application is not apparent. The term "pitch diameter" commonly used in America is not good either. The term "mean diameter" is correct, as it means exactly what the term implies—that is, the diameter of the screw taken midway between the root and outside diameters.

VOLUME OF STEAM AT A GIVEN PRESSURE

A. E. H.—Is there any way that I can find the volume occupied by, say, 6 pounds of dry and saturated steam at a gage pressure of, say, 100 pounds per square inch, without the use of a steam table?

A.—Rankine's formula will probably give results sufficiently exact for your purpose; this formula is:

$$PV^{\frac{17}{16}} = 475$$

where P = absolute pressure in pounds per square inch;

V = volume in cubic feet occupied by one pound of steam.

The absolute pressure = gage pressure + pressure indicated by the barometer; if the latter is not known, it is customary to call it 14.7. In this case we have:

$$P = 100 + 14.7 = 114.7$$

$$PV^{\frac{17}{16}} = 114.7V^{\frac{17}{16}} = 475$$

Taking the logarithm of both sides of this equation:

$$\text{Log } 114.7 + \frac{17}{16} \log V = \log 475$$

$$\text{Log } V = \frac{16}{17} (\log 475 - \log 114.7) = \frac{16}{17} (2.67669 - 2.05956) = 0.58083.$$

$V = 3.8092$ = number of cubic feet occupied by one pound of steam under the above conditions. The volume occupied by six pounds is:

$$3.8092 \times 6 = 22.8552, \text{ say } 22.86 \text{ cubic feet}$$

The logarithm of any number (or quantity) having an exponent is equal to the logarithm of the number multiplied by the exponent; for instance, $\log A^c = c \times \log A$. J. J.

EXPLANATION OF THE TERM "FUNCTION"

C. O. T.—Quite frequently of late I have encountered the term "function"; please explain what it means.

A.—The labor of a mathematical investigation is greatly simplified by reason of numerous definitions and symbols that have been universally agreed upon. Among these, one of the most useful is the term "function" and its symbol. The area of a circle may be expressed mathematically as $A = \pi R^2$, in which $\pi = 3.14159 +$. The quantities A and R are called variables, since their values may be changed (varied) at will; π is called a constant, since its value is unchangeable. Note that the value of A cannot be determined until some value has been assigned to R; hence, A is called the dependent variable and R is called the independent variable. The entire expression πR^2 is called a function, or, more precisely, a function of R; and since A equals this expression, A is frequently called the function and R is called the variable. We may now define a function as any mathematical expression containing at least one variable, provided that when a definite value is assigned to the variable, a definite value results for the function. Thus, $x^2 + (a + x)(a - x)$ is not a function, because it is equal to a^2, an expression that does not contain a variable, a being a constant. The constants are usually represented by the first letters of the alphabet and the variables by the last letters, corresponding to the known and unknown quantities in algebra. When we do not wish to write the expression for the function, we symbolize it by enclosing the variable in parentheses, and to further identify it, write a letter, usually f or ϕ, before it. The above function could then be expressed $A = f(r)$ or $A = \phi(R)$. J. J.

FORCED FITS OF WHEELS AND AXLES

L. F. S.—Please advise as to the best modern practice in making allowances for forced fits of railway and street car wheels and axles. I have been working to the old rule of 0.005 inch plus 0.001 inch for each inch of diameter. With these allowances, from eight to ten tons pressure per inch diameter are required to assemble. Any reference that you can give will be appreciated.

A.—Authorities do not agree on allowances for forced fits of railway wheels and axles, but their disagreement may be more apparent than real, owing to factors not being considered or mentioned that vitally affect the result. In the first place, the finish and truth of the axle seat and the bore are important. In the October, 1912, number of MACHINERY an article appeared entitled "Wheel and Axle Pressed Fits," which included a table giving the diameters of fifty-two axle and wheel fits. The diameters of the axles were given at the outside and inside ends of the seat for both wheels, and the bore diameters of the wheels were given at the inside and outside ends also. These data showed that the axle seats are hardly ever of the same diameter at both ends, and the wheel bore diameters also vary from end to end; variations of 0.003 or 0.004 inch are common. Depth of cut and feed were given with these examples which, too, are important. A coarse feed permits the use of greater allowance than a fine feed and smooth finish. With the depth of cut 1/32 inch and feed 1/8 inch, the rule referred to by you agrees pretty closely with the allowance given for an axle 6 inches diameter forced into a cast-iron wheel. The allowance was 0.011 inch and the pressure required was fifty tons. But with smooth, true axle seats and wheel bores, less allowances than the rule calls for are advisable, about 0.001 inch per inch diameter being sufficient.

COLLAPSING PRESSURE OF PIPE

O. J. R.—In Merriman's "Mechanics of Materials," the following formula is given for the collapsing pressure of wrought-iron pipe, in which T, L, and D are the thickness, length and diameter, respectively, in inches, and P is the pressure in pounds per square inch:

$$P = 9{,}600{,}000 \frac{T^{2.18}}{LD}$$

He gives as an example, find T when $P = 120$ pounds per square inch, $L = 72$ inches, $D = 4$ inches, and the factor of safety = 10. By substitution in the formula:

$$T^{2.18} = \frac{10 \times 120 \times 72 \times 4}{9{,}600{,}000} = 0.036$$

From which, by the help of logarithms, he finds $T = 0.22$ inch. Please show me how to use logarithms to find T.

A.—Taking the logarithm of both sides of this equation:

$$2.18 \log T = \log 0.036 = \bar{2}.55630$$

$$\text{Log } T = \frac{\bar{2}.55630}{2.18} = \bar{1}.33775$$

$$T = 0.21765 = 0.22 \text{ inch, very nearly}$$

We presume that your trouble lies in performing the division, which may be done in two ways: First, make the dividend entirely negative by subtracting the positive mantissa from the negative characteristic (*i. e.*, add them algebraically),

the result being -1.44370. Dividing this by 2.18, the quotient is -0.66225; and in order to get the mantissa positive, we add -1 and $+1$ (which of course does not change its value) and obtain:

$$-1+1-0.66225 = -1+0.33775 = \bar{1}.33775$$

Second, if we add -0.18 to the negative characteristic, it becomes -2.18, which is exactly divisible by the divisor; but, if this be done, $+0.18$ must be added to the mantissa.

Hence:

$$\text{Log } T = \frac{-2+(-0.18)+0.18+0.55630}{2.18} = \frac{-2.18+0.73630}{2.18} =$$

$$-1+0.33775 = \bar{1}.33775$$

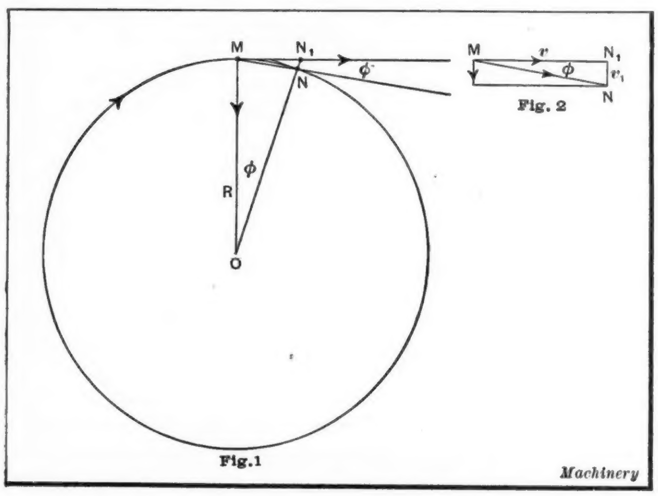
The number whose logarithm is $\bar{1}.33775$ is 0.21765, or, say, 0.22.

CENTRIFUGAL FORCE

J. A. G.—Please state what is meant by centrifugal force and show how the formula $F = 0.000341\,wrn^2$ is derived.

A.—Whenever a body moves in a curved orbit, it must be continually acted upon by some external force, since, otherwise, according to the first law of motion, it would move in a straight line. If the orbit be a circle and the body attached to a string, the external force is the pull exerted on the body by the string, the direction being radial; it is, consequently, always perpendicular to the direction of motion of the body, which, for any point, is the tangent to the circle at that point. Thus, in Fig. 1, when the body is at M and revolving in the direction indicated by the arrow, its direction of motion is along the tangent MN, and the pull of the string is along the radial line MO, acting from M toward O. The pull is called the centripetal force, and the reaction, or pull exerted by the string on the center, is called the centrifugal force. Note that the centrifugal force is a reaction only and cannot produce motion. If the string be cut when the body reaches M, it will immediately move along the tangent MN with the same velocity that it had when moving in the circle. Since the centripetal force is always radial, it is always perpendicular to the direction of motion, and exerts no influence whatever toward changing the circumferential velocity of the body; it is also a constant force, and whenever a constant force acts on a moving body, it produces, in this case, a constant acceleration toward the center. The body, however, always stays at the same distance from the center, because the centripetal force is always only sufficient to change its path from a straight line to a circle. Suppose the body to have a velocity v; then, in a small interval of time t, it will move from M to N through the angle ϕ. During this time, it will have a constantly accelerated motion toward the center, the velocity being $v_1 = at$, in which a is the acceleration. If the body had not been deflected, it would have arrived at the point N_1 in the same time. Draw N_1N, ON, and MN; then, if the angle ϕ is minute, N_1N will practically coincide with ON and will be perpendicular to N_1M. Also, the angle N_1MN will then equal $MON = \phi$. Now draw the parallelogram of velocities, Fig. 2, in which $MN_1 = v =$ the circumferential velocity of the body, and $N_1N = v_1$ perpendicular to MN_1. Therefore, $\tan\phi = \frac{v_1}{v} = \frac{at}{v}$. But when the angle ϕ is extremely small, the tangent may be considered equal to the arc; hence, $\phi = \frac{at}{v}$. Letting R = radius of circle, arc $MN = vt$, and $\phi = \frac{vt}{R} = \frac{at}{v}$; whence, $a = \frac{v^2}{R}$. Letting M be the mass of the body and F the centripetal force or its equal, the centrifugal force, $F = M \times \frac{v^2}{R} = \frac{Mv^2}{R} = \frac{Wv^2}{gR}$, in which W is the weight of the body and g is the acceleration due to gravity. Taking g as 32.16 feet per second per second, v is in feet per second; if n = number of revolutions per minute, $v = \frac{2\pi Rn}{60}$, and $F = \frac{W}{32.16R}\left(\frac{2\pi Rn}{60}\right)^2 = 0.000341\,WRn^2$.

J. J.



Figs. 1 and 2. Diagrams illustrating Meaning of Centrifugal Force

MOMENT OF INERTIA

W. B. D.—Why is the product Ar^2 called the moment of inertia?

A.—According to the first law of motion, every body continues in a state of rest or of uniform motion in a straight line unless acted upon by some external force that compels a change. Consequently, if the motion or direction of motion is changed, it must be due to some external force and work must be done on the body. A rotating body is constantly changing its direction of motion; therefore, regardless of whether or not its angular velocity changes, a force must act and work must be done if the body continues to rotate. Referring to the illustration, let the disk M rotate about the axis through O; then all particles M_1, M_2, etc., turn through equal angles M_1ON_1, M_2ON_2, etc., $= \phi$ degrees during a small interval of time t. If the radius of the circle $A_1B_1A_2B_2$ be unity, arc A_1B_1 = arc A_2B_2 = etc. $= \phi = \frac{\phi}{180} \times \pi$ = angle in radians. The angular velocity of any particle is $w = \frac{\phi}{t}$, and the angular acceleration is $k = \frac{w}{t}$, in which w is the increase of angular velocity in the time t. Letting $M_1O = r_1$, $M_2O = r_2$, etc., the actual distance passed through by M_1 is $s_1 = \phi r_1$; by M_2 is $s_2 = \phi r_2$, etc. The linear velocity of M_1 is $v_1 = wr_1$; of M_2 is wr_2, etc. The linear acceleration of M_1 is $a_1 = kr_1$; of M_2 is $a_2 = kr_2$, etc. The mass M of the whole body is the sum of the masses of the particles $M_1 + M_2 + M_3 +$ etc., which are at distances from O equal to the radii r_1, r_2, r_3, etc., and the forces with which these particles *resist* turning are $F_1 = M_1a_1 = M_1kr_1$; $F_2 = M_2kr_2$; etc. The moments of these forces about O are $F_1r_1 = M_1kr_1^2$; $F_2r_2 = M_2kr_2^2$; etc. Hence, the moment of the force that turns the entire body with the angular acceleration k is (see figure) $F \times c = M_1kr_1^2 + M_2kr_2^2 +$ etc. $= k(M_1r_1^2 + M_2r_2^2 + M_3r_3^2 +$ etc.$)$. Since the sum of all the masses M_1, M_2, etc., is equal to the entire mass M, we may write for the sum in parentheses the single term Mr^2, and we have $I = Mr^2 = M_1r_1^2 + M_2r_2^2 + M_3r_3^2 +$ etc. The quantity I is called the moment of inertia; it is a measure of the force required to rotate a body. M may be replaced by any quantity proportional to it; and since the area of a surface is proportional to its mass or weight, we may write for the moment of inertia of a surface $I = Ar^2 = A_1r_1^2 + A_2r_2^2 + A_3r_3^2 +$ etc.

J. J.

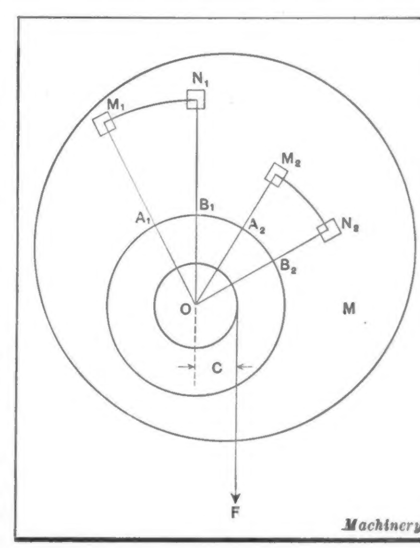


Diagram illustrating Significance of Term Moment of Inertia

DEFINITION OF "SPECIFIC"

A. A. K.—Please explain what is meant by the word "specific" in such terms as specific weight, specific pressure, specific volume, etc.

A.—The specific weight of any material is the weight of a unit of volume of that material, as the weight of a cubic foot, a cubic meter, etc.; specific pressure is the pressure per unit of area, as the pressure per square inch, per square centimeter, etc.; the specific volume of any material is the volume of a unit weight of that material, as the volume of a pound, a kilogram, etc. It will thus be seen that in every case the word "specific" implies comparison with a unit, as distinguished from total weight, total pressure, total volume, etc. Thus, specific resistance of wire is resistance of a unit of length of the wire. J. J.

LAYING OUT A CURVE IN ISOMETRIC PROJECTION

P. H. K.—The diagram at *X* in Fig 1 illustrates a problem which has given me some trouble and for which I have been unable to find a solution. Let it be required to draw in isometric projection the curve *AGF* in the rectangle *ABDC*. Laying out the isometric rectangle shown at *Y*, I obtained the form *A'B'D'C'*, and using the common method of determining the centers for the arcs, these centers are found to be at the intersection of the dotted lines at *R* and *S*. With radii equal to *RA'* and *SF'*, respectively, and using the two centers mentioned, it is seen that the arcs do not become tangent to each other at *E'*, but rather intersect and overlap each other on each side of this point. I should appreciate a solution of this problem, as it seems to me that as the radii for the curve shown in the rectangle *X* are equal, those in the isometric rectangle should also be equal and should produce the required curve in isometric projection.

A.—It must be remembered that isometric drawing is not true for every condition. This is especially the case in curves or circles which are tangent to each other and which are foreshortened like those shown. In a great many cases the method used in Fig. 1 can be applied to advantage, but when it is necessary to have an accurate delineation, the curve or curves must be obtained by another method called plotting. The method shown at Fig. 1 can be considered as an approximate method which is easier in its application and is used more frequently than the other, although the errors in delineation sometimes lead to complications in the construction of drawings, for example, when drawing a sphere, in circumscribing or inscribing a circle, or when a portion of the circle fits into or joins some other part or parts of an irregular figure.

In plotting the curves shown, a method by ordinates is used as follows: Referring to Fig. 2, the rectangle *ABDC* is constructed at *X* and the curve *AGF* laid out correctly with equal radii swung from the centers at *E* and *B*. Each complete arc of the circle is divided into six equal parts, from which ordinates *H, I, J, K, L, O, N*, and *M* are erected, perpendicular to the base of the rectangle, and from the same subdivisions on the arc other ordinates *H', I', J', K', L'*, and *P', K', O', N', M'*, are drawn parallel to the base line. In drawing the isometric rectangle *A'B'D'C'*, these ordinate spacings are laid out along the lines *E'F'* and also along the vertical lines *A'C'* and *B'D'*. At the proper intersection of the various lines as indicated at *X*, the curves are plotted so that the connected points form the foreshortened isometric curve *A'G'F'* shown at *Y*.

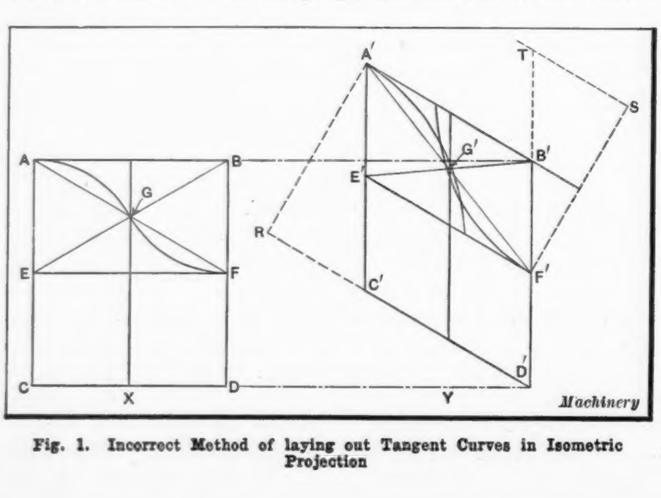


Fig. 1. Incorrect Method of laying out Tangent Curves in Isometric Projection

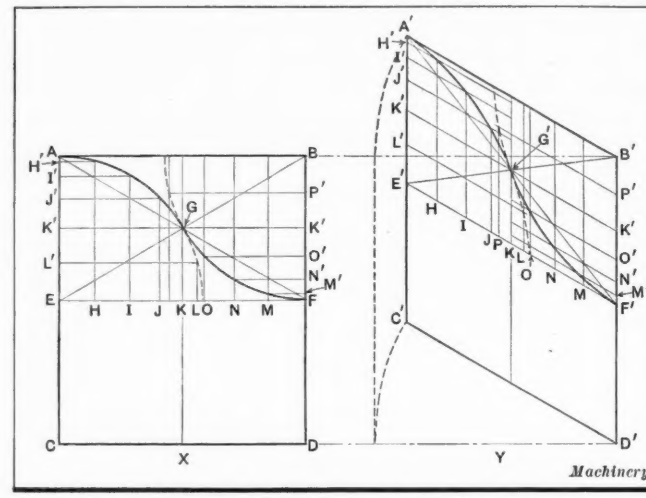


Fig. 2. Plotting Tangent Curves in Isometric Projection

FORCE OF IMPACT OF BALL AGAINST BAT

W. M. F.—A cricket ball weighing 4½ ounces (0.28 pound) is bowled at a velocity of 30 feet per second. What must be the force with which the bat returns the ball, assuming that the velocity of the returned ball is 30 feet per second and that the time of impact of the ball against the bat is 1/80 second? The answer is 15.82 pounds.

A.—Either the answer is wrong or the problem is not stated correctly, as the following considerations show. The force of a blow is determined by the following formula, $ft = mv$, in which f = force of impact, t = time required to bring body to rest, m = mass of body (in this case, the ball), and v = velocity of ball, all quantities being measured in similar units. If the ball were perfectly inelastic and were thrown against a solid, smooth, stone wall, there would be no rebound and the entire time of impact would be absorbed in bringing the ball to rest. The striking force would then be $f = \frac{mv}{t} = \frac{wv}{gt} = \frac{0.28 \times 30}{32.16} \div \frac{1}{80} = \frac{0.28 \times 30 \times 80}{32.16} = 20.9$ pounds. This force is exactly the same as would be required to give the ball a velocity of 30 feet per second in 1/80 second, and is the smallest possible effect that could be produced by a ball having this weight and velocity. If the ball were perfectly elastic, it would first be flattened by the impact and would then expand to its original form, the time of compression and of restitution being equal. The time of compression is the time required to bring the ball to rest and equals $1/80 \times 1/2 = 1/160$ second. The ball would bound back with the same velocity it had when striking, and the force of the blow would be $20.9 \times 2 = 41.8$ pounds. Evidently, the effect of the bat is just this, since it returns the ball with the same velocity it had when striking. However, the ball is not perfectly elastic; hence it does not entirely regain its shape during contact. If we take the index of elasticity as 0.9, the velocity after impact is $30 \times 0.9 = 27$ feet per second, and the excess, $30 - 27 = 3$ feet per second, must be made up by the bat in 1/160 second; that is, the striking force must equal $41.8 + \frac{0.28 \times 3 \times 160}{32.16} = 45.97$ pounds. The time of compression and the time of restitution during impact are assumed to be equal in all cases. J. J.

* * *

We have been informed by the Greenfield Tap & Die Corporation that the statement in the description of the Greenfield "gun tap" as to the origin of the term is incorrect. It is not true that the term originated because this type of tap has been largely used in gun work, but it owes its name rather to the fact that the tap "shoots" its chips straight ahead in long, unbroken curls.

SPECIAL MACHINES FOR MAKING FUSE PARTS

MAXIMUM PRODUCTION OBTAINED BY THE USE OF HIGHLY SPECIALIZED MACHINES AND EQUIPMENT FOR DRILLING AND MILLING OPERATIONS

THE tremendous production required in the manufacture of munitions has led to the development of many special types of machines for performing various operations in a minimum amount of time and within the required limits of accuracy. Fuse parts are required in great numbers for shrapnel and high-explosive shells, and, as a consequence, the processes of manufacture have received the most careful consideration. Some of the parts which go to make up the fuse have a number of angular holes drilled in them, all of which are closely grouped within a small circle, so that the requirements are rather severe if the holes are to be drilled simultaneously. Even when the drilled holes are not angular their compactness necessitates the spindles with which they are drilled to be set in a very small compass. It is evident that in order to produce work of this kind to the best advantage, it is necessary to use machines capable of high spindle speeds and which are very nearly automatic in their action and not likely to get out of alignment. The machines illustrated and described in this article have been developed by the Langelier Mfg. Co., Providence, R. I., especially for use in the manufacture of fuse parts. The numerous angular holes, powder passages and wrench flats to be machined in these parts can be produced with great rapidity.

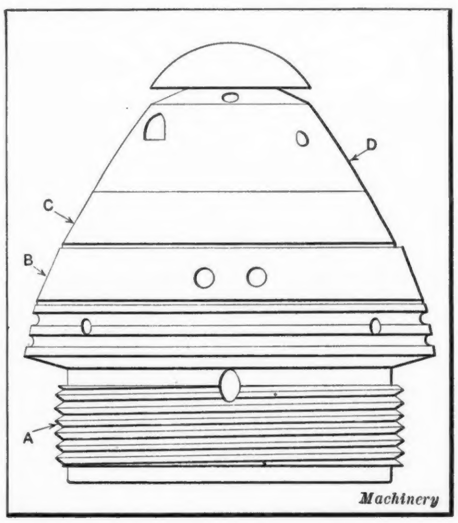


Fig. 1. Assembled View of Russian 75-millimeter Shrapnel Fuse

Fig. 1 shows an outline drawing of an assembled fuse for the Russian 75-millimeter shrapnel shell. In this illustration *A* is the fuse body, *B* is the graduated time train ring, *C* is the top time train ring, and *D* is the closing cap. Some of the other parts of the fuse are not shown in this assembly drawing, as they form a part of the inside construction, but they will be mentioned and shown in detail in a subsequent part of the article.

Machining Operations on Closing Cap

The closing cap, shown in detail in Fig. 2, is made from aluminum which has been die-pressed into a form that closely approximates the finished piece. The process employed in die-pressing castings was described in MACHINERY, January, 1916, in an article entitled "The Production of Die-Pressed Castings." After the castings have been die-pressed as mentioned, they are drilled, counterbored, formed, threaded, etc., on horizontal screw machines prior to the drilling and milling operations.

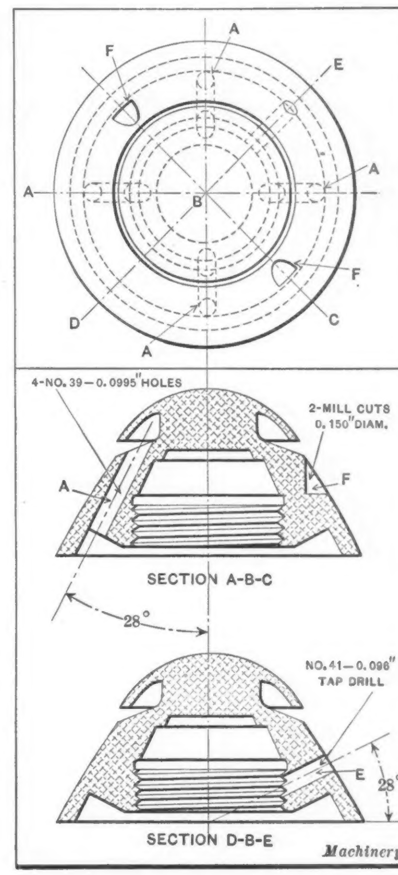


Fig. 2. Aluminum Closing Cap used on Shrapnel Fuse

Duplex Milling Machine for Closing Cap Wrench Notches

Referring again to Fig. 2, it will be seen that the section A–B–C shows one of the wrench notches *F*. These cuts are to be milled on opposite sides of the piece, as indicated in the upper view, and the machine shown in Fig. 6 has been especially designed for this work, so that both slots are milled simultaneously. Fig. 6 shows a view of the complete machine, while Fig. 4 shows a more detailed view of the working parts. Referring to Fig. 4, the closing cap *A* is located and held in position by a pressure spindle *B*. The head of the spindle is formed to fit the recess in the base of the cap, and no rotary location is necessary, because the milling operation is done prior to the drilling of the angular holes. The pressure spindle is actuated by a foot-treadle *C*, Fig. 6, having a link, lock-toggle and segment gear connection *D* to the spindle. An adjustable stop *E* is so arranged that the spindle movement can be easily adjusted to the proper milling position. A spring abutment bar *F*, having a sliding movement and located between the milling spindles, is used to hold the work against the pressure spindle while it is advanced to and from the correct milling position.

The milling spindles *G* run in double taper adjustable phos-

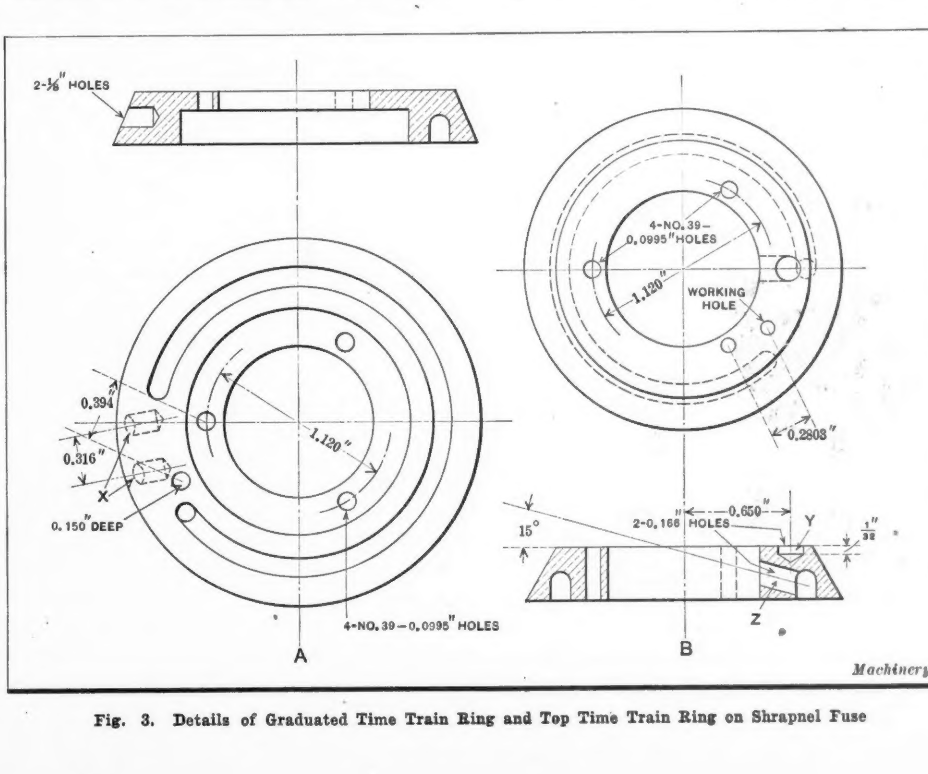


Fig. 3. Details of Graduated Time Train Ring and Top Time Train Ring on Shrapnel Fuse

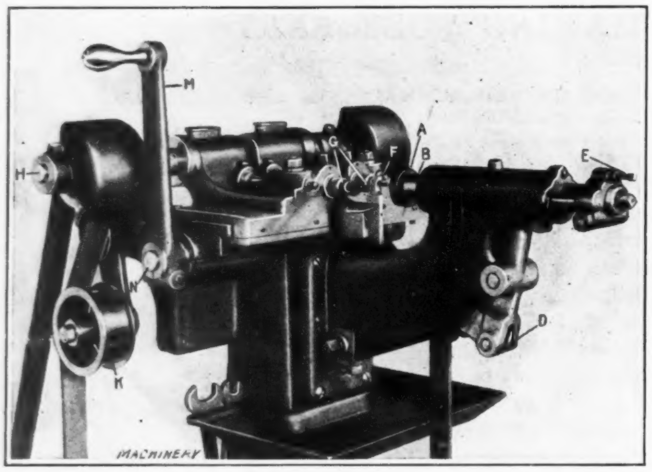


Fig. 4. Detail of Spindle and Operating Mechanism on Duplex Milling Machine for Closing Cap

phor-bronze bearings in cross-heads mounted adjacent to each other on saddles that feed crosswise to the axis of the spindles upon a long slide. These spindles are fitted with ball thrust bearings and the cross-heads are adjusted longitudinally so that the mills can be set to the required cutting depth. The spindles are driven by spiral gears from separate driving shafts on each side of the machine, these shafts being belted over the idler pulleys K to the countershaft L fastened to the column at the rear of the machine. The feed is actuated by hand-lever M mounted on the end of shaft N which is located lengthwise at the center of the saddle slide. The shaft has short lengths of right- and left-hand threads of coarse pitch that mesh with segment nuts fastened to each of the saddles and cause the milling heads to feed toward or away from each other in unison. Adjustable stops limit the amount of feed.

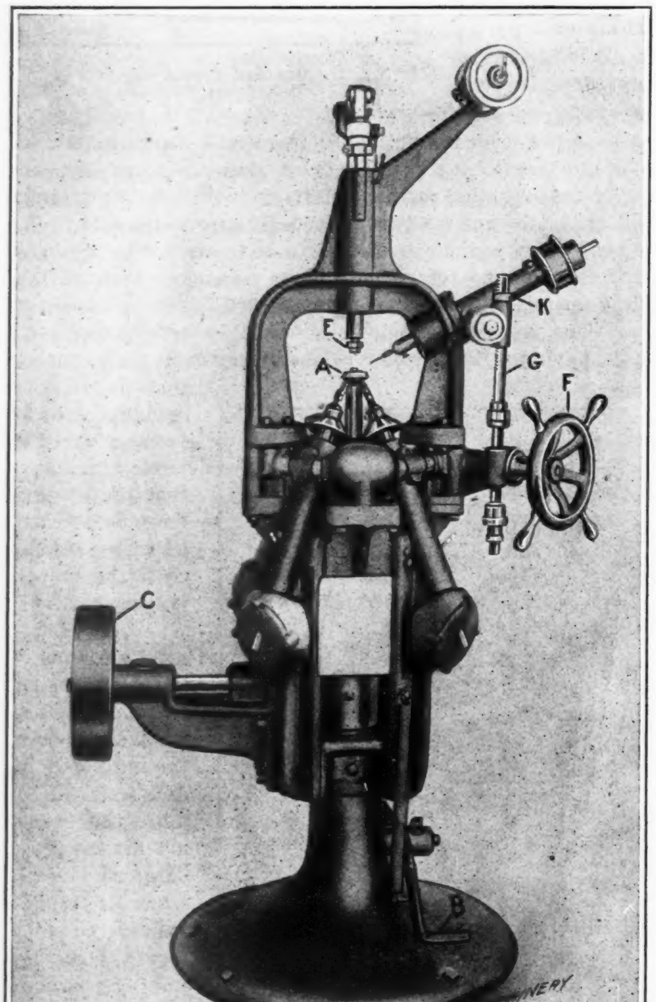


Fig. 5. Special Five-spindle High-speed Drilling Machine for Shrapnel Fuse Closing Cap

To operate the machine, the workman proceeds as follows: He locates the work on the head of the pressure spindle and holds it until it is brought into contact with the abutment bar, after which he advances the work to the milling position by depressing the foot-pedal and keeping it in this position. The milling is done by moving the hand-lever one-third of a turn downward, which advances the spindles toward each other, thus cutting the required slots in the work. After returning the hand-lever to its starting position, the operator releases the foot-pedal and holds his hand in such a position as to catch the work when it falls off the end of the work-

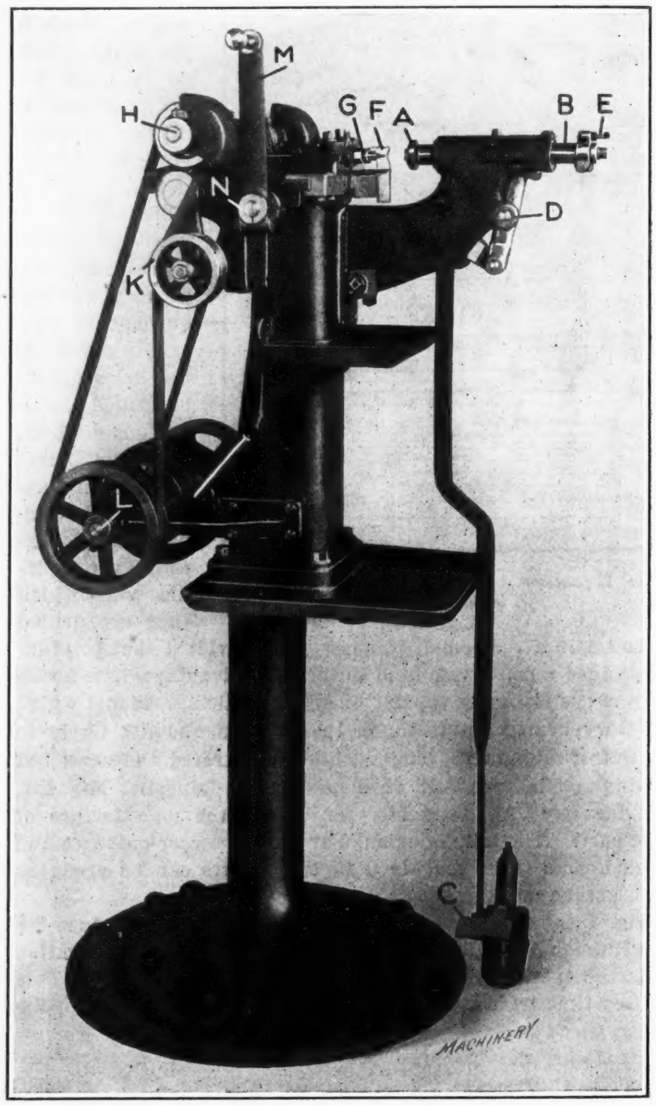


Fig. 6. Special Duplex Milling Machine for Wrench Slots in Closing Cap

holding spindle and breaks contact with the abutment bar. The machine is provided with belt tighteners and shifters and also a pan of suitable form for catching the chips. The end-mills are 0.150 inch in diameter and run at a speed of 2500 R. P. M. The output is five per minute, or 3000 per ten-hour day.

Five-spindle Angular Drilling Machine

Referring to Fig. 2, five angular holes A and E will be noticed. The holes A are at an angle of 28 degrees from the perpendicular, while the hole E is at 28 degrees from the base line. Fig. 5 shows a five-spindle high-speed drilling machine designed to drill all these holes simultaneously. The work A is located in the drilling position by a special jig with five drill guide bushings that is set on top of a central post which is vertically adjustable. The piece to be drilled is held on the jig by the pressure of plunger E which is operated by the foot-treadle B. The four lower drilling spindles are located 90 degrees apart and converge toward a common center, while the upper spindle is above the others and midway between two of them. The four lower spindles are driven

through bevel gearing by the main driving pulley C at the left of the machine. The upper spindle is belted direct to the countershaft through the pulley shown. All the drilling spindles are fed by the spider handwheel F in connection with a bevel gearing, rack and pinion mechanism G. The upper spindle feed can be disconnected from the lower so that the drilling position of each can be adjusted independently. The spindles are also provided with drill collets that are adjustable longitudinally for fine adjustments and to make up for the shortening of the drills caused by regrinding. An adjustable stop K is used on the vertical feed rack for limiting the drilling depth.

The jig is surrounded by a flared edge pan, and all gearing is encased or covered by suitable guards to prevent the chips from falling onto the lower spindles. The machine is driven by a separate countershaft running at 500 R. P. M. and the drills are speeded to 2000 R. P. M. The output of the machine is ten pieces per minute.

Machining Operations on Top Time Train Ring

Fig. 3 shows a detail drawing of the top time train ring at B and the graduated time train ring at A. These two pieces are both made from tobin bronze and are machined from the bar on a multiple-spindle automatic screw machine. The drilling of the four No. 39 0.0995-inch holes in each of the time train rings is done on a No. 2 Langelier multiple drilling machine illustrated in Figs. 7 and 9. Fig. 7 shows the entire machine, while Fig. 9 shows a detail of the drilling head with the various drills in position and the jig in place on the table. A machine of this type is also used for the bottom closing screw, the percussion primer screw and the percussion plunger (details of which are shown in Fig. 17), the jigs being arranged to suit the conditions and the spacing of the holes. The spindles also must be arranged to fulfill the drilling requirements. Referring to Fig. 7, it will be seen that the spindle head carrying the various drills is arranged so that the cage acts as a flexible clamp which comes down upon the work after the latter is located in the fixture shown on the table. The cage also is provided with bushings through which the various drills pass, thus insuring their proper location. There are projecting prongs that exactly locate the parts to be drilled by pressure as the head comes down.

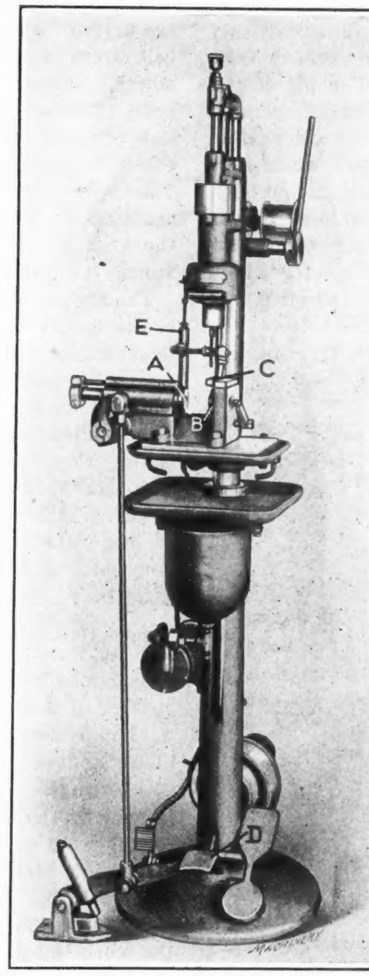


Fig. 8. High-speed Drilling Machine arranged for drilling Radial Holes in Graduated Time Train Ring

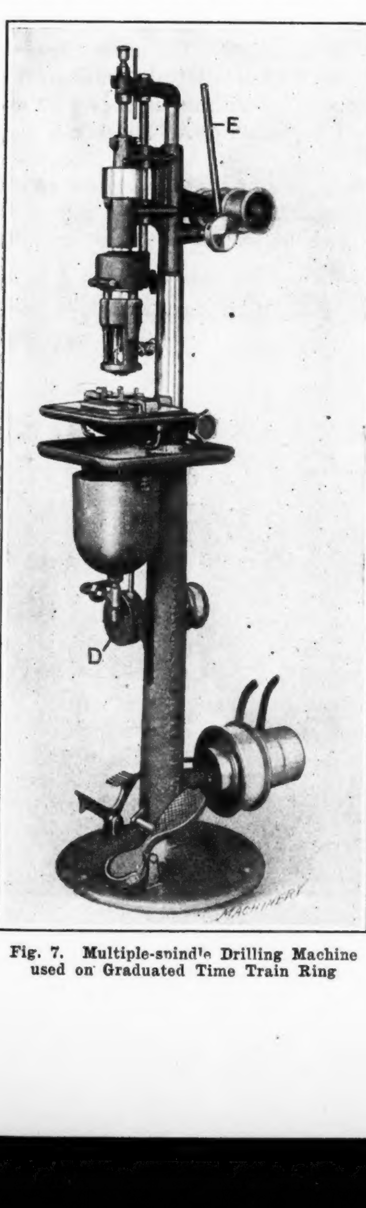


Fig. 7. Multiple-spindle Drilling Machine used on Graduated Time Train Ring

Fig. 9 shows clearly the construction at this point. Attention is called to the fact that lubrication of the drills is controlled by means of the spindle movement through arm B which actuates a valve through plunger A, thus opening and closing the supply pipe at predetermined points which can be regulated to a nicety by means of the check-nuts shown. The surplus lubricant drains off into the reservoir beneath the table, where it is strained and used over again, being forced through the pipes by the pump D, Fig. 7. When the output of any one of a number of parts is sufficient to keep a machine continuously in operation, a machine and head can be furnished as a unit to apply to this machine. If the amount of work to be done is not sufficient to keep one machine busy continuously, one or more heads with a different lay-out of spindles can be made to fit interchangeably on the same machine. The drill heads with their steadyrests are self-contained and may be readily interchanged.

In the construction of this machine the heads and drivers are made from phosphor-bronze and the drilling spindles are of a special steel which permits a deep case-hardening, so that they can be accurately ground to size, thus leaving a hard bearing surface with a tough but soft center. The feed is actuated by the hand-lever E in conjunction with a rack and pinion. The spindle pulley runs on sleeves anchored in the housing of the machine, thus avoiding pull of the belt on the main driving spindle. Loose perforated bushings are used in all running bearings, thereby increasing the wearing surface and insuring a free distribution of the oil. Reference to Fig. 7 will show that the belt can be shifted from the tight to the loose pulleys by means of the operator's foot, this arrangement being very convenient in the high-speed production of parts. The production on the top time train ring B is three pieces per minute, while the graduated time train ring A can be produced at the rate of five pieces per minute.

Drilling Wrench Holes in Graduated Time Train Rings

Figs. 8 and 11 show, respectively, the machine for drilling the two holes X shown in Fig. 3, and a detail view of the work-table with the fixture in place. The type of jig used on this machine is designed to drill single or double holes in the periphery of cylindrical work at right angles to the axis. The construction of the jig is simple, consisting of a work-holding plunger A on which the

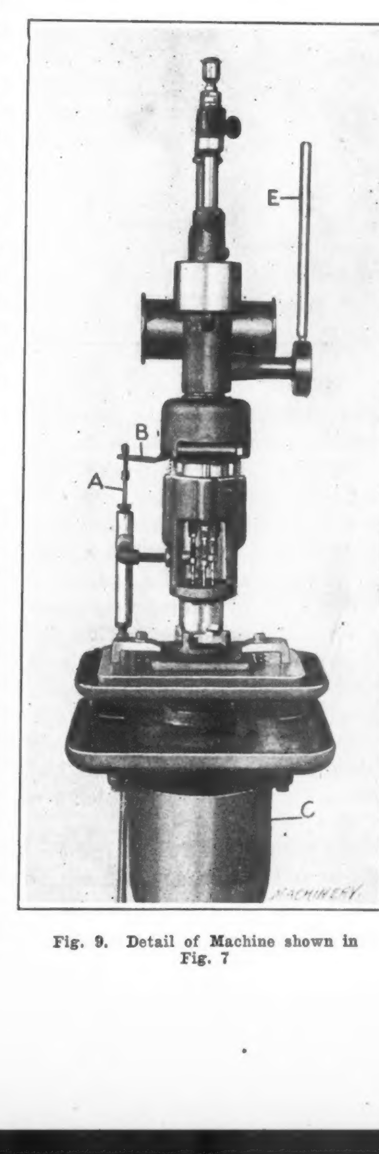


Fig. 9. Detail of Machine shown in Fig. 7

piece is located; an ejector; and a faceplate *B* on which is mounted a bushing plate *C* which locates the drills correctly with respect to the work. The jig is of the stationary type, being bolted to the drilling machine table. The plunger *A* is provided with a rack controlled by a gear segment operated by the foot-lever *D*. The plunger is brought forward against the faceplate *B*, thus securely clamping the work while it is being drilled. The plunger is returned to its original position by means of a compression spring inside the holder, and as it returns a pawl engages a ratchet in the shaft which carries the segment, thus bringing into action an ejector which automatically releases the work at the end of the stroke so that there is no interference in loading the next piece.

Both the plunger and faceplate are used in locating the work, the former being provided with a locating pin which engages a working hole in the ring while the faceplate is integral with the plug which fits the inside diameter of the work and locates it centrally. In operation, the work is slipped loosely onto the plunger and turned about until the pin and working hole engage, when a pressure of the foot-lever brings the plunger and work against the faceplate and under the drill spindle, simultaneously clamping the work. The drilling is accomplished by operating either the hand- or foot-lever. After drilling, the foot-lever operating the jig is released and the work automatically ejected. The rate of production is about 300 pieces per hour, using a carbon drill, as the material from which the pieces are made is bronze. The supply of lubricant is automatically controlled, as in the preceding instance, by the plunger which operates a valve in the barrel at *E*.

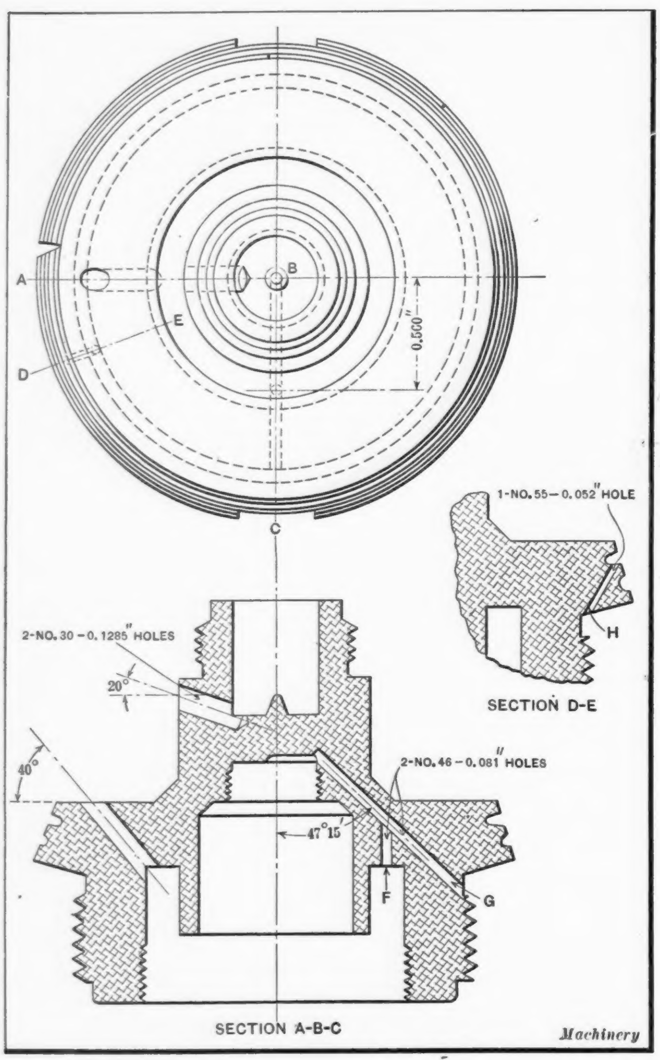


Fig. 10. Detail of Fuse Body

The holes *Y* and *Z* in the top time train ring are drilled one at a time on a No. 2 single-speed motor bench drill, a special jig being used; the net output is about six holes *Y* per minute and three holes *Z* per minute. The spindles on machines of this kind are driven directly by a belt from a 1/6-horsepower, alternating-current, 220-volt Holtzer-Cabot motor, giving a speed of 2500 R. P. M. The operation of the machine is similar to the type that was previously described.

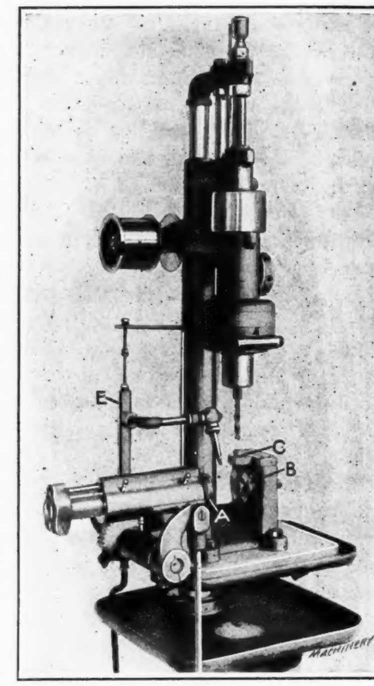


Fig. 11. Detail showing Jig Construction for Wrench Holes in Graduated Time Train Ring

The angular periphery of the timing train ring is graduated in seconds, starting at zero and running up to 21 seconds. The graduating of the timing ring is done on a special marking machine which was described in the article on shrapnel manufacture, MACHINERY, April, 1915.

Machining Operations on Fuse Body

The fuse body shown in Fig. 10 is made from a hot-pressed brass blank and is machined on an automatic screw machine in two settings. The first series of operations, in which the work is held by the small end in a collet chuck, consists in rough-forming the outer diameter and drilling out and trepanning the inside, performing the various operations on the inside of the work and finally cutting the thread on the outside. In performing the second series of operations on the fuse body, the work is located by being first screwed into a special bushing by means of which it is held in the collet. The remainder of the work on the small end of the piece is now finished in the same type of machine as that used for the first series of operations.

There are several holes to be drilled in an angular direction in this piece of work, the arrangement for drilling one of these being clearly shown in Figs. 12, 13 and 14. The machines used for these operations are of the high-speed ball bearing type. They can hardly be termed special machines, as they will not become useless if the present demand for shells should suddenly cease.

Referring to Fig. 12, *A* shows one of these machines of the single-spindle type arranged especially to drill the hole *F* in the work shown in Fig. 10. This hole must be drilled parallel

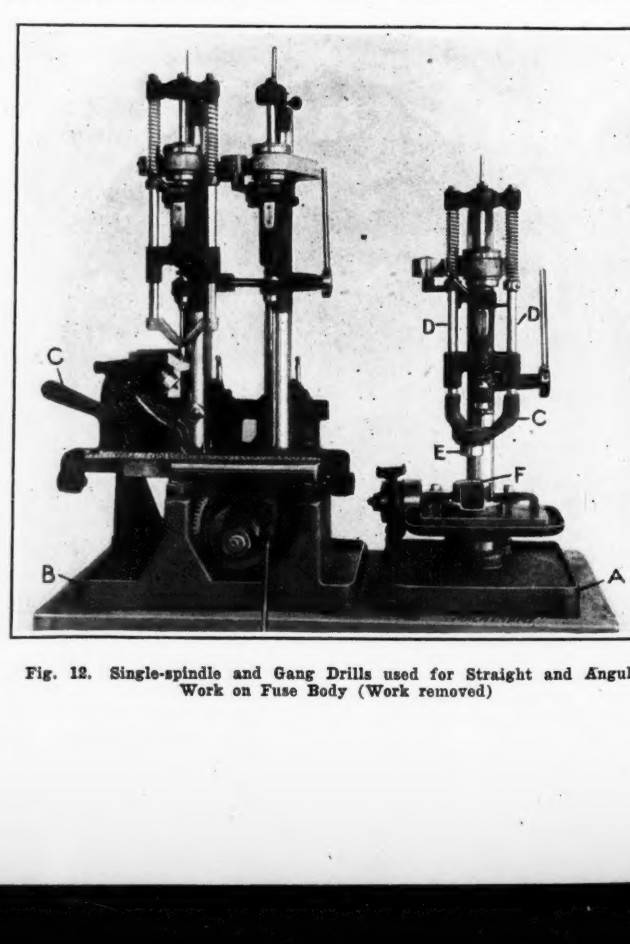


Fig. 12. Single-spindle and Gang Drills used for Straight and Angular Work on Fuse Body (Work removed)

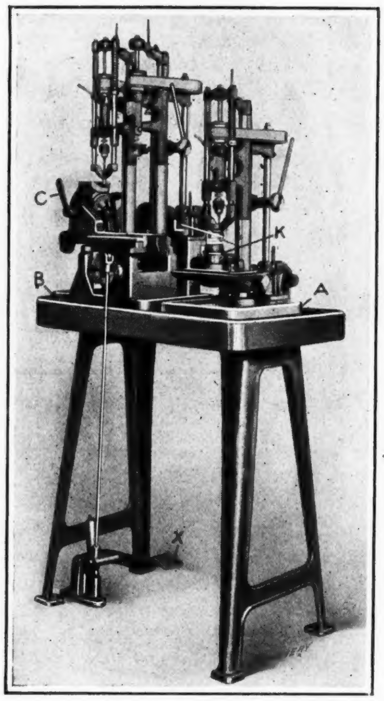


Fig. 13. Gang and Single-spindle Drilling Machines for drilling Fuse Body, showing Work in Position

with the axis of the fuse body and at a distance of 0.560 inch from the center line. This machine is almost identical with the regular No. 1 high-speed drill produced by the Langelier Mfg. Co., but a jig C is attached to the sliding rods D parallel to the axis of the spindle. It will be seen that the drill jig is thus located directly underneath the chuck and that the drill runs in it in a hardened and ground bushing. In the jig, a hardened plug E, having the same diameter as the inside of the work, locates the fuse body at the proper center distance, and a locating pawl (more clearly shown at K in Fig. 13), provided with a trigger, engages a slot in the rim of the work, thus insuring the correct location of the drilled hole. The floor plate or body of the jig F is clamped to the drill table directly under and in line with the locating plug, sufficient room being allowed between it and the jig to permit the operator to work rapidly without interference. In loading, the spindle is brought to the normal or upper position shown in Fig. 12, while the left hand of the operator depresses the trigger on the locating pawl. The work is then placed on the plug and the trigger released while the piece is twirled until the pawl engages the slot. The spindle is now lowered and the lower face of the fuse body L comes in contact with the floor plate as shown in Fig. 13. The springs on the side rods of the jig hold the piece securely while the spindle is brought down. After the drilling operation has been completed, the spindle is raised to its normal position and the drilled work removed.

The advantages of a jig of this kind are readily apparent, as the work to be machined is loaded in such a position that little trouble is likely to be caused by chips. There are no blind corners or pockets in which the chips may accumulate, so that the cleaning is very easily done. Another point worthy of note in connection with this method of drilling is that when the work is in place, the point of the drill is only 1/16 inch from the work, so that it enters the piece almost immediately after the work is clamped. Another advantage lies in the fact that the operator wastes no time in bringing the drill bushings into line with the spindle after loading, as is usual with the detached type of jig.

A machine of this type can readily be adapted to other classes of work by merely constructing a jig suitable for the piece to be machined and securing the jig to the sliding rods. Practically any number of holes may be handled economically, provided they are in a circle and of the same radius. By removing the jig and sliding rods entirely, the machine may be used as a regular high-speed bench drill. As a matter of fact, it is a high-speed drilling machine which can be readily adapted to many kinds of work, and the unit construction of machines and jigs which can be easily arranged to suit a given condition will appeal to any manufacturer having large quantities of work to be machined at a minimum of expense.

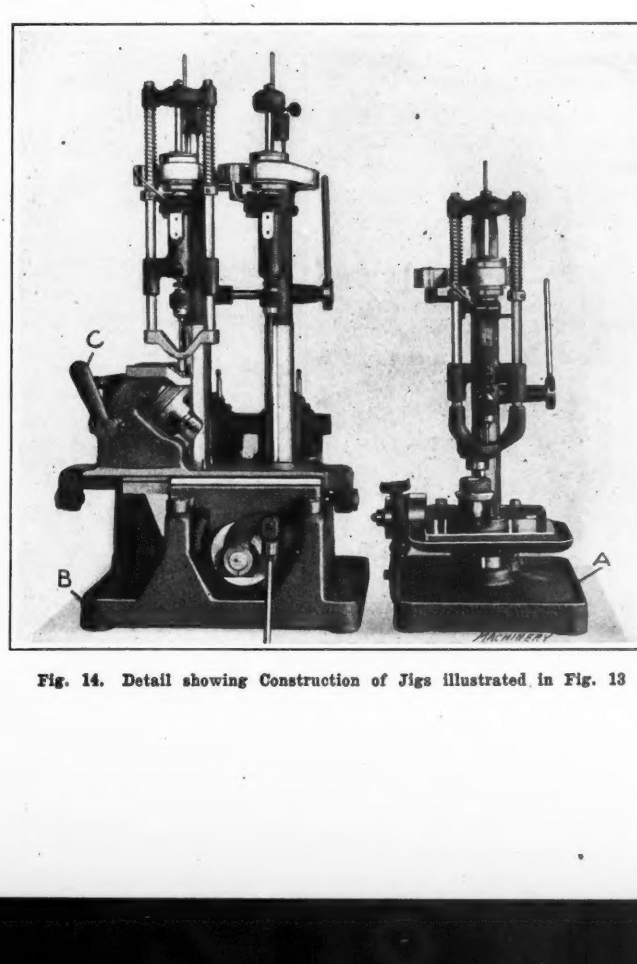


Fig. 14. Detail showing Construction of Jigs illustrated in Fig. 13

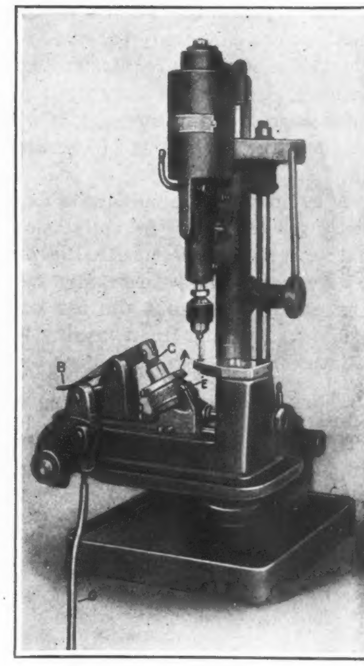


Fig. 15. Machine used for drilling Angular Hole in Fuse Body

The machine shown at B is of the two-spindle gang type, designed to handle work requiring drilling, counterboring or reaming at one setting or for drilling several holes having very close center distances, so that it is not possible to have two or more spindles perform the drilling operations simultaneously. If desired, one of the spindles can be slowed down for reaming or other operations requiring a slower speed than drilling. In the example shown, however, the spindles are run at a uniform speed of 5000 R. P. M. Reference to the illustrations will show that the machine is really composed of three units, consisting of a two-spindle gang drill, a bed, and a carriage, the latter combining the features of a jig in its construction. Should it be desired to use the machine as a two-spindle gang drill only, a table may be substituted for the jig and slide. Another departure from the usual practice lies in the fact that both spindles are operated by one feed lever, thus effecting a considerable saving in time over machines having independent feeds on both spindles. It has been found that in the majority of cases one independent adjustment is sufficient for the reaming or counterboring operations, so that the reamer or counterbore can be adjusted to the proper depth of cut while the drill is set at a suitable height to correspond with it. When it is necessary to make accurate adjustments, micrometer collets or independent stops can be used.

In operation, the work is loaded with the jig as shown under the left-hand spindle, and the first operation is completed by feeding the spindle down. After the first operation has been accomplished, the spindle is elevated and the foot-lever shown at X in Fig. 13 is pressed by the operator so that the jig is carried under the second spindle for the next operation. By releasing the foot-lever, the carriage automatically springs back to the first position, pneumatic buffers absorbing the shock as the carriage strikes the stop. The stops on each end are adjustable to compensate for wear, and the gibs on each side of the bed can be adjusted to take up the wear on the carriage so that it can be correctly aligned.

In ordinary process, when a detached type of jig is used, slip bushings are commonly provided for the jig where tools of different diameters are required to complete an operation. In this machine, however, a steady jig is provided for the first spindle, which carries a slip bushing in which the drill is running all the time the machine is in operation. A liner bushing is provided in the jig proper so that the slip bushing enters the liner as soon as the spindle is depressed. When the carriage is transferred to the second station, the stops are so arranged that it comes to rest with the drill hole directly under the spindle, and it may be readily seen that accurate results are thus obtained without the use of a second slip bushing. It is obvious that the liner bushing is made large enough so that the second tool clears the sides by a safe margin.

Jigs for Angular Hole in Fuse Body

The operation performed by the two-spindle gang drilling machine *B* is the drilling and counterboring of the 0.081-inch hole *G* at an angle of 47 degrees, 15 minutes from the vertical center line, the hole being required to meet the 0.081-inch hole

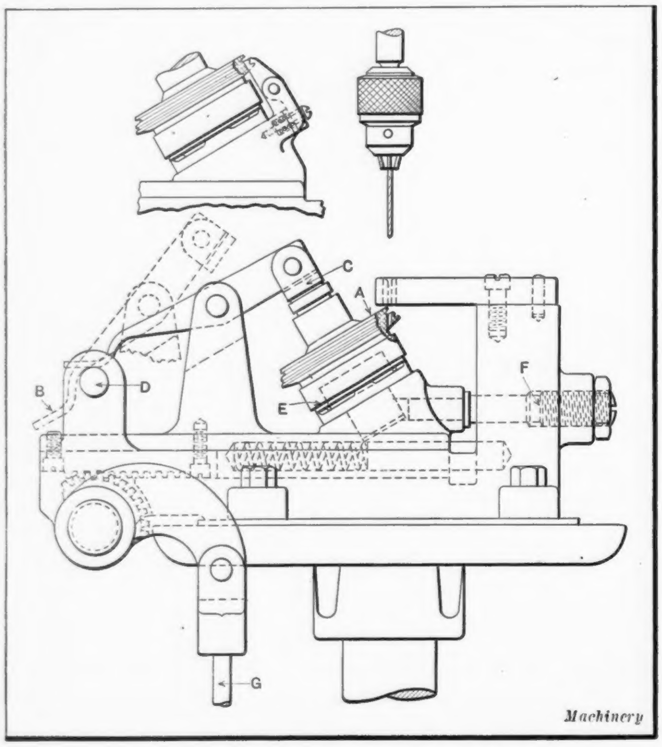


Fig. 16. Detail of Fixture shown in Fig. 15

F previously drilled by the single-spindle machine *A*. The work is located in much the same manner as on the single-spindle drilling machine, by means of a hardened plug, while a locating hole provides the correct alignment for the two holes. The method of clamping in this instance, however, is accomplished in a somewhat different manner: the hand-lever *C* at the front of the jig operates a toggle joint which, in turn, actuates a fulcrumed jaw. In clamping, the hand-lever brings the toggle joint a trifle beyond the dead center, securely locking the piece against a floor plate which is integral with the locating plug. The counterbore on the second spindle enters the drilled hole and counterbores this to a depth of 0.100 inch and to a diameter of 0.125 inch. In this connection it is of interest to note that during the automatic return of the carriage, an expert operator can remove the finished work before the carriage comes to rest at the first station, so that a minimum amount of time is lost between the cuts. It must not be inferred from this that the return movement of the carriage is slow, but the general design is such that the operator has both hands free at this time, and can therefore handle the piece very rapidly. The shock of the return stroke of the carriage is regulated by a pneumatic buffer, while the automatic return of the carriage can be adjusted to a slow or fast rate of movement by turning a drum that carries a flat spiral spring.

Adaptation of Single-spindle Drilling Machine for Drilling an Angular Hole in the Fuse Body

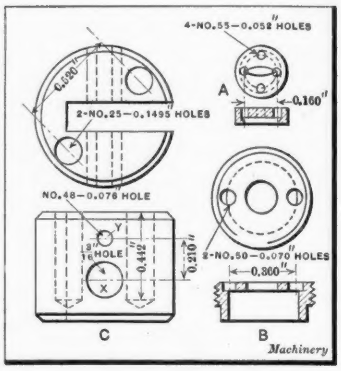


Fig. 17. Detail of Fuse Parts. (A) Concussion Primer. (B) Percussion Primer Screw. (C) Percussion Plunger

Fig. 15 shows one of the high-speed sensitive drilling machines arranged with a special high-speed jig for drilling the hole *H*, Fig. 10, in the fuse body. Fig. 16 shows a construction drawing of the jig. The hole for which this jig is adapted is 0.052 inch, drilled at an angle of 30 degrees from the vertical axis through the flange of the fuse body. Owing to the fact that the hole starts at an extremely steep angle, and is located against a floor plate and plug by the inside diameter of the work, it is necessary to so design the jig that the bushing can be brought very close to the work and at the same time allow space for loading and unloading. By making the locating and clamping device on the sliding principle operated by a foot-lever, segment and rack, this difficulty is easily overcome. The slide and bed are scraped to a bearing with gibs to compensate for wear.

As in all other drilling operations on the fuse body, the hole is located from a notch in the rim of the flange, the locating pawl (shown in Fig. 16) engaging with this notch to insure proper location. The spring tempered bar *B* carrying a floating jaw *C* is pivoted to the slide in such a way that when the latter is brought under the bushings, the feathered end of the spring bar rises on a cam *D* and brings the jaw firmly down on the work, clamping it against the floor plate *E* while the adjustable stop *F* locates the slide in the proper place under the bushing. In operation, the work is located on the plug with the slide back and is twirled around until the locating pawl engages, after which it is pressed down against the floor plate by the action of the spring bar as the slide is carried forward under the spindle. The foot-lever,

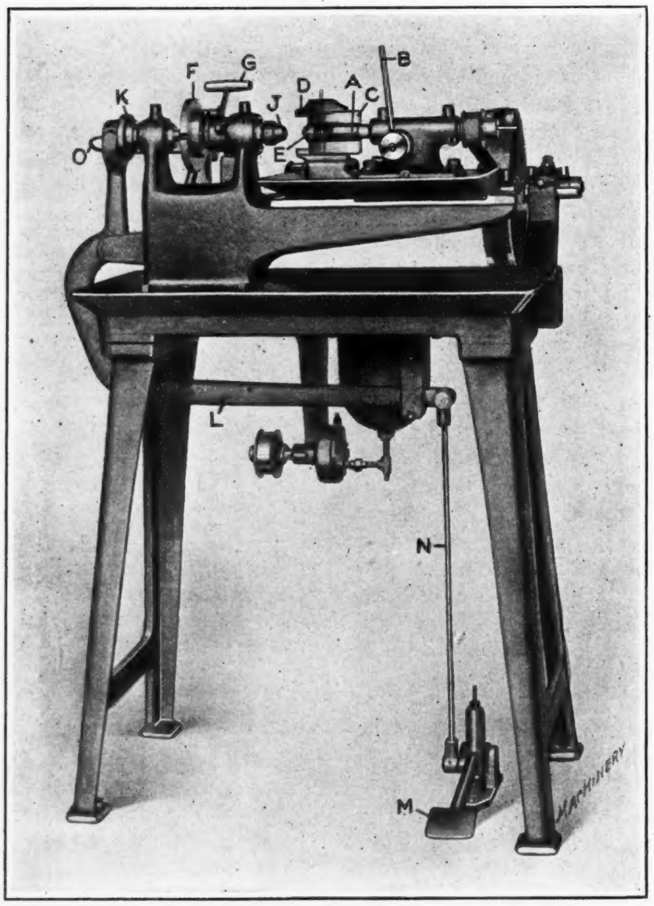


Fig. 18. Front View of High-speed Horizontal Drilling Machine with Indexing Attachment, used in drilling Concussion Primer

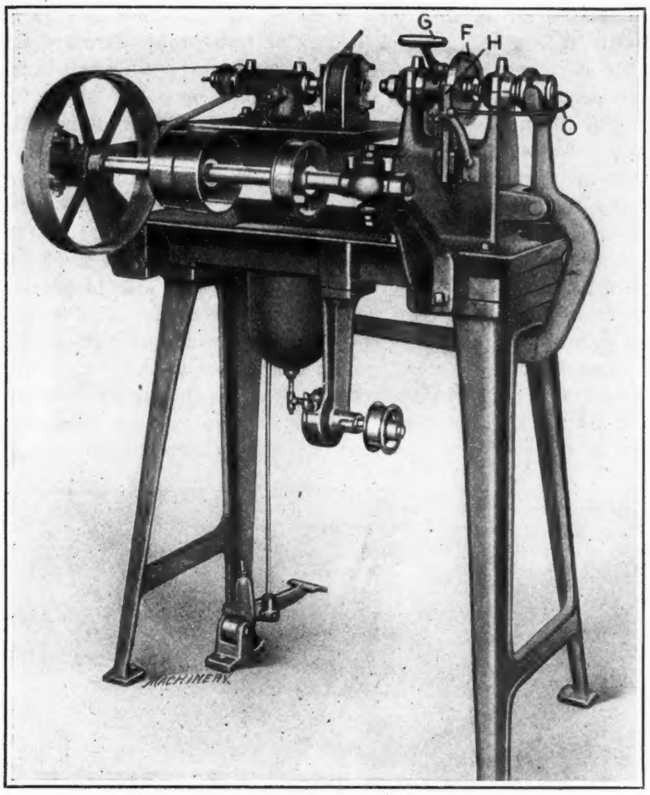


Fig. 19. Rear View of Machine shown in Fig. 18

being connected to the rod *G*, operates the entire mechanism, and as it is released after the drilling operation, the slide springs back to the loading position, releasing the work so that the operator can readily supply the jig with another piece. The output on this machine with the mechanism shown and using carbon drills is about 350 pieces per hour, and the drill speed is approximately 9000 R. P. M.

Machining Operations on Concussion Primer, Percussion Plunger, and Percussion Primer Screw

The concussion primer, percussion plunger, and percussion primer screw are made of brass and are machined, prior to drilling, on automatic screw machines. Referring to Fig. 17, *A* shows a detail of the concussion primer. Figs. 18 and 19 show, respectively, the front and rear views of the high-speed light drilling and indexing lathe designed especially for drilling the four holes in the piece mentioned.

The drilling is done by a light, sensitive spindle *A* which is fed by a hand-lever *B* at the front of the tailstock. The chuck end of the sleeve is provided with a sliding steadyrest *C* that travels in a guide *D*. In this steadyrest is a drill bushing *E* that supports and accurately starts the drill. In drilling, the steadyrest is fed up until it comes to a stop against the work being drilled, while the drill itself continues and performs the drilling operation. The spindle pulley runs on a sleeve clamped into the rear end of the tailstock and drives the drilling spindle by means of a double keyed collar fastened to the pulley, insuring a sensitiveness that is very desirable when drilling small holes. The spindle is driven by a 1-inch seamless belt from a countershaft fastened to the back of the machine, in connection with which a belt tightener is provided.

The headstock is a casting having an extending slide upon which the tailstock can be adjusted to its proper drilling position. The spindle in the headstock is provided with a four-notch index wheel *F* that is actuated through a ratchet and pawl by means of a hand-lever *G*, so as to bring each of the four holes in the percussion primer successively into line with the drilling spindle. The spindle is locked during the various drilling operations by the lever *H* shown in Fig. 19. A transverse adjustment to the tailstock makes it possible to locate it in any desired position, so that holes can be drilled in various diameters of circles. The spring chuck *J* is controlled by a sliding thimble connection on the left end of the machine, this spindle being actuated by the long bent lever *L* which passes underneath the table and is connected by means of a link rod *N* to the foot-pedal *M*. The chuck is closed by a heavy compression spring when the operator removes his foot from the pedal. After being drilled the work is automatically ejected by a jet of compressed air provided through a small shut-off valve that is open only during the interval that it takes to move the index wheel. The valve is connected to the rear end of the spindle by a brass tube *O*. The output on this machine is four completely drilled pieces per minute, or 240 per hour. The drill size is No. 55, 0.052 inch, and the drills are especially tempered and run at a speed of 6000 R. P. M.

Machining Operations on Percussion Plunger

Owing to the fact that the holes *X* and *Y* in the percussion plunger *C*, Fig. 17, are only 0.210 inch apart, it would be difficult to drill them simultaneously from the same side of the piece. Hence, the two-spindle opposed drilling machine shown in Fig. 21 was designed. The work-holding fixture is in the form of a vise, the jaws of which can be seen at *E* in Fig. 21, and it is only necessary for the operator to insert the pieces to be drilled between the jaws. In order to do this the work is placed on the end of the reciprocating pressure plunger *A* that slides in a holder fastened to the air cylinder on the front of the machine, and that is actuated by a foot-pedal *B* through a rack and pinion. As the foot-pedal is depressed, the work is advanced between the vise jaws to its proper drilling position. The operator then raises the feed lever *C* so as to feed both drilling spindles toward the piece from each side at the same time. As the feed lever is elevated, an air valve is automatically opened, letting compressed air at about 45 pounds pressure per square inch into an air cylinder *F* fastened to the front of the machine underneath the vise. The upward movement of a piston in this chamber causes a U-shaped yoke attached to it to close the vise upon the piece to be drilled. After the drilling operation has been completed, the return of the feed lever causes the air valve to exhaust

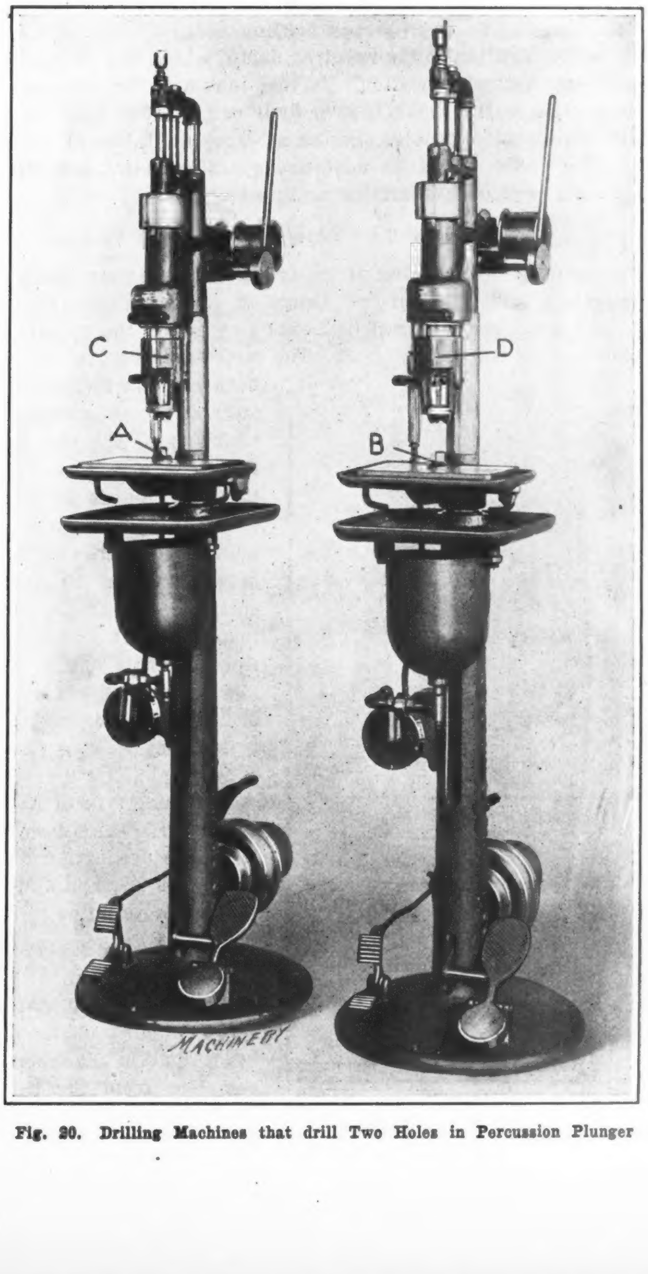


Fig. 20. Drilling Machines that drill Two Holes in Percussion Plunger

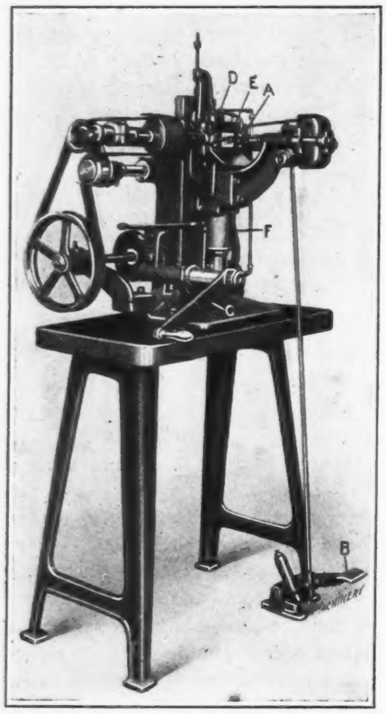


Fig. 21. Duplex Drilling Machine for Percussion Plunger

the cylinder automatically and the vise jaws to open. The foot-pedal is now released, causing the pressure plunger to return to its loading position. The exhaust air from the cylinder is piped to blow away and clear the vise of chips after the piece has been ejected from the vise.

The drilling spindles are belted over idler pulleys to a driving shaft at the rear of the machine. All pulleys and the driving shaft run on ball bearings. In order to avoid the use of a crossed belt for driving the right-hand spindle, a three-pulley construction is used that reverses the motion by driving from the back of the belt. One of the quarter-turn pulleys for each acts as a tightener. The method of feeding the drilling spindle is by means of the hand-lever *C*, connected to a shaft which, in turn, is geared to a vertical slide at the rear of the machine. This slide carries two wedge cams that are fastened to the inner ends of feed yokes, the outer ends of which have a clamp connection to the drilling spindle, this connection being used to set the spindles to their proper drilling positions. A stop is provided for drilling to the required depth, which is adjustable to suit any normal condition. In this instance, the left-hand spindles that carry the 3/16-inch drill run at 2666 R. P. M., while the opposite spindles, having a No. 48 drill, run at 3838 R. P. M. Under a test an unskilled operator maintained an output of five pieces per minute on this machine.

Drilling and Reaming Two Holes in Percussion Plunger

The drilling and reaming of the two holes in the percussion plunger are performed on two Langelier No. 2 multiple drilling machines having special jig heads attached to the spindles as shown at *C* and *D* in Fig. 20. The tables are provided with fixtures having rectangular pieces *A* and *B* which enter the slot in the work, and it is centered by means of the projecting points on the drill head, while it is held in place by the spring as in the other instances. The production on this piece is about three pieces per minute. The percussion primer screw shown at *B* in Fig. 17, is drilled on the same type of machine with a suitable jig. The production on this piece is about four pieces per minute.

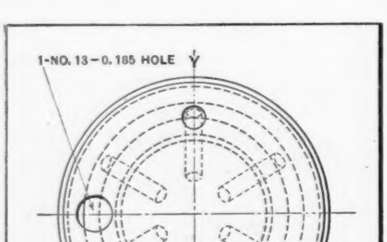


Fig. 22. Detail of Bottom Closing Screw

Machining Operations on Bottom Closing Screw

The bottom closing screw is also made of brass and is machined complete from the bar on an automatic screw machine prior to drilling. A detail of the piece is clearly shown in Fig. 22, in which it may be noted that there are six holes angularly placed in the piece and converging to a common center. These holes are to be made by a No. 39 0.0995-inch drill, and the machine designed especially for doing this work is shown in Fig. 23. The work is located in the drilling position by means of a jig head *A* that is mounted centrally among the drilling heads. The inner terminal of travel of the jig is the drilling position, while the outer terminal is the loading and ejecting position. This arrangement is made in order to facilitate the jigging of the work and also to protect the operator's hands from contact with the drills. The traveling spindle is actuated by the operator through a push-treadle *B* by means of a rack and pinion connection to the rod shown. The work is held in its correct position in the jig by an abutting spring plunger *C* that carries two pins which enter the No. 30 0.1285-inch holes that have been previously drilled.

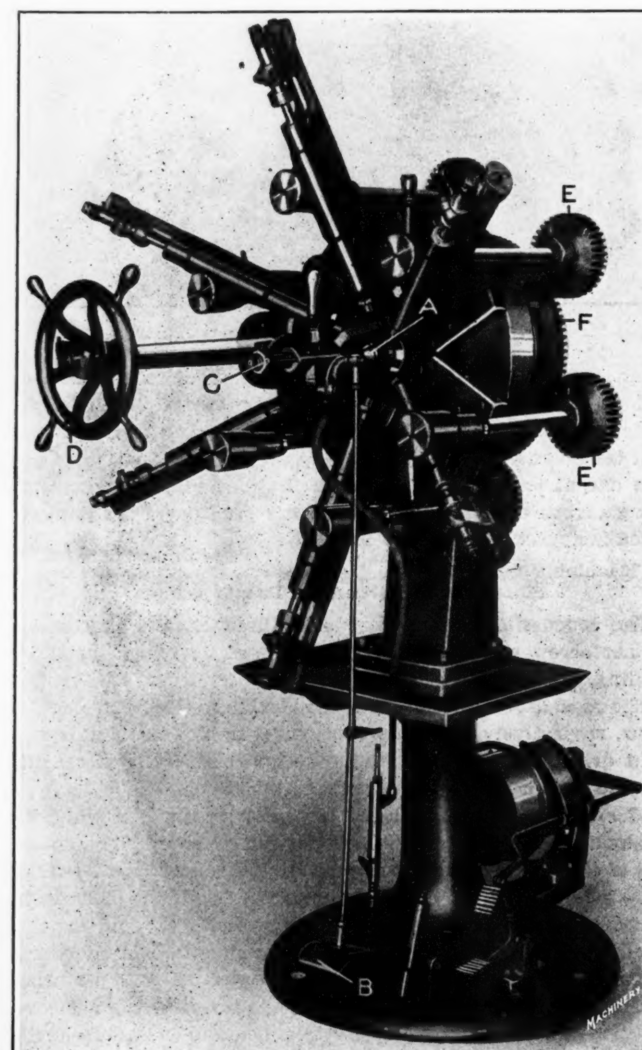


Fig. 23. Six-spindle High-speed Drilling Machine for drilling Angular Holes in Bottom Closing Screw

The feed of the drilling spindle is actuated by the handwheel *D* mounted on the end of a pinion shaft that meshes with a rim gear located inside the faceplate to which the drilling heads are attached. The rim gear carries segment cams which engage with roll levers that actuate the yoke. The spindles are driven by spiral gears, the drivers of each head extending to the rear and meshing with the main spindle driving gear *F*. The running thrust of the driver shaft is taken by ball thrust bearings.

The various machines described and illustrated in this article form a group which has greatly reduced the cost of production on fuse work, and while some of the machines have been designed entirely for increasing the production on the work shown, others are very similar to the standard type of machines built by the Langelier Mfg. Co., with special features to suit the particular cases shown throughout the article.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

CLEVELAND FULL AUTOMATIC MOTOR-DRIVEN MACHINE

There are numerous automatic screw machine operations in which it is desirable to make a change of speed during the operation, typical examples being found in cutting off, forming parts from square or hexagon stock, drilling, reaming, etc. To secure increased efficiency through the possibility of effecting such a change in speed, an automatically controlled motor drive has been developed for use on Cleveland automatics with provision for making any required changes of speed during the performance of a single operation or between successive operations. It consists of a controller box with levers that are actuated by cams on a drum, the cams being set in suitable relation to the tools so that speed changes will be made at the proper points in the cycle of operations.

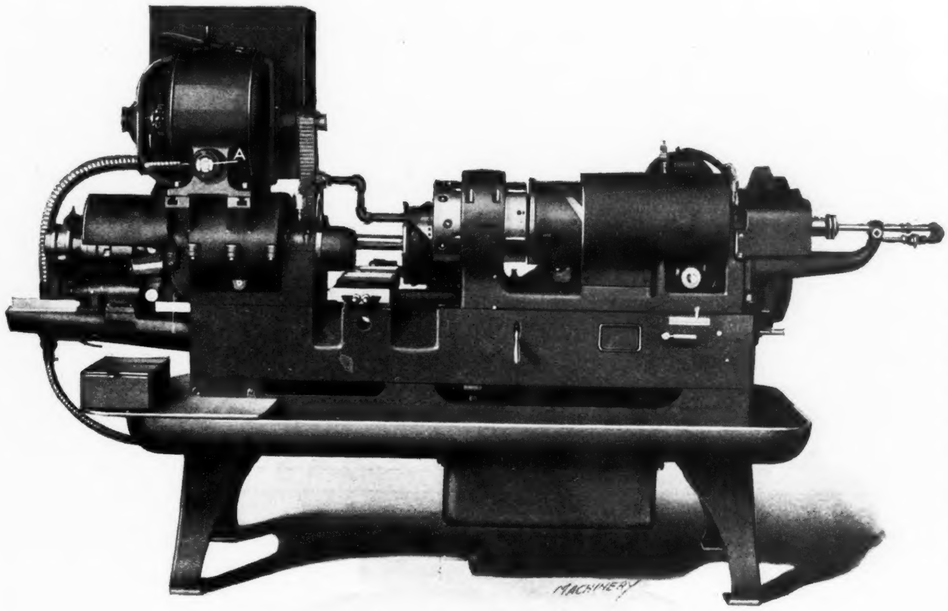


Fig. 1. Front View of Cleveland Full Automatic Motor-driven Machine

The Cleveland Automatic Machine Co., Cleveland, Ohio, has recently developed an automatically controlled motor drive for use on automatic screw machines of its manufacture, which is the means of increasing efficiency of operation and rate of production. Figs. 1 and 2 show one of the new machines equipped with the automatic motor drive, from which it will be seen that the design is the same as that of the well-known Cleveland automatic with the exception of the electrical equipment. This consists of a three-to-one variable-speed, quick-reversing inter-pole motor, direct connected by a silent chain to the spindle driving gears. The speed range of this motor is doubled by means of two sets of driving gears in the spindle head, either one of which may be automatically engaged. At the other end of the machine is a small constant-speed, compound-wound pilot motor which is direct connected by a silent chain to the feed driving mechanism and oil pump of the machine. Two motors are used, because the drive of the spindle is entirely independent of that of the feed, which gives the advantage of being able to obtain any one of a large number of different spindle speeds without in any manner affecting the feed mechanism of the machine. This is the most important gain to be had in a motor-driven machine over that of the belt drive, as it means the possibility of the correct peripheral speed for each tooling operation and therefore increased output.

The machine is controlled by means of a push-button for both starting and stopping. Directly back of the large motor is a panel upon which are mounted accelerating units for both motors, an overload relay coil for each motor, and the automatic main switch. On account of the fact that all the electrical equipment is wired as a unit, one push-button controls the starting and stopping of both motors; and an overload on either motor instantly stops the entire machine. No fuses are required in any part of the apparatus. Referring to Fig. 2, at the extreme right-hand end of this view may be seen the speed control apparatus. This is a cast-iron box *A* containing thirteen levers, eight of which are for the purpose of regulating the speed of the variable motor; three are for controlling the direction of rotation, either forward, reverse or stop; and two are for shifting a clutch by means of a double-acting solenoid. Directly above the speed box is a cam drum *B* upon which are mounted small adjustable cams which operate the levers in the speed box *A*.

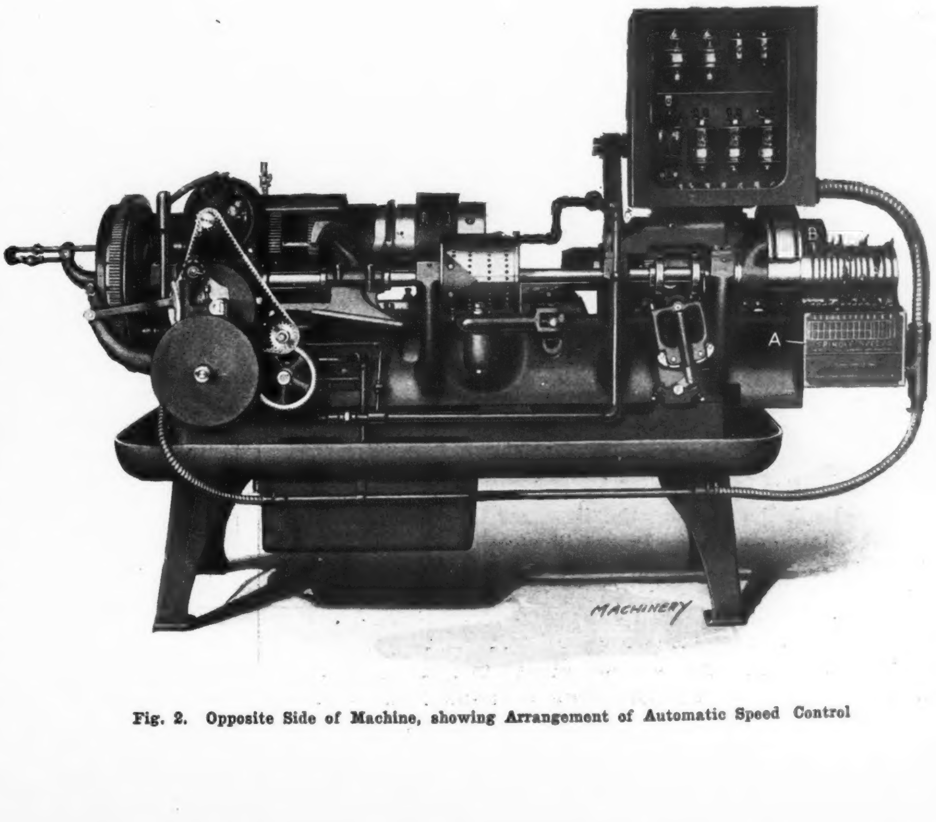


Fig. 2. Opposite Side of Machine, showing Arrangement of Automatic Speed Control

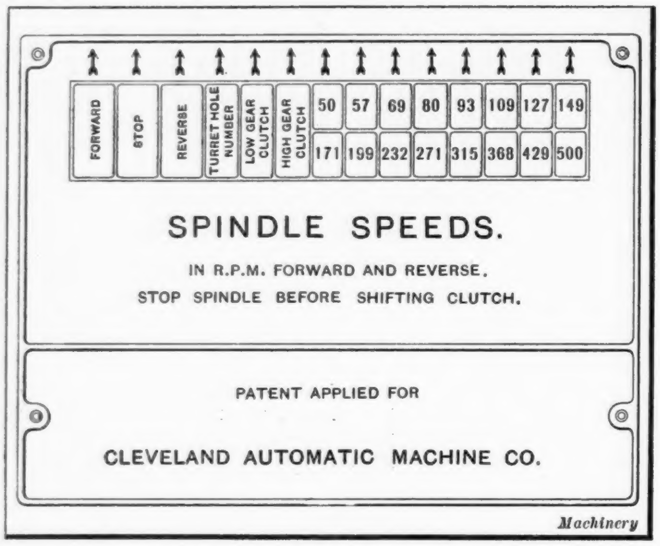


Fig. 3. Plate on Speed Control Apparatus that serves as Guide in setting Cams

Fig. 3 is a diagram showing exactly what may be obtained by means of the mechanism just described. The arrows at the top of Fig. 3 point directly to the cams above them on the machine, showing which cam should be used to obtain any one of the speeds or direction indicated. The speeds which are obtainable on the 2-inch machine are here indicated, and it will be noted that there are sixteen different speeds from the lowest, which is 50 revolutions per minute, to the highest, which is 500 revolutions per minute, and that these speeds step up in regular progression. All these speeds may be used in either direction or the spindle may be stopped dead if desired for any purpose, all this being done without in any way interfering with the feed control of the machine. Any one of the entire range of speeds in either direction may be thrown into engagement at any time, as the act of tripping in any speed automatically throws out the speed which was previously engaged, and no harm can come at any time by accidentally engaging two or more speed levers at the same time.

Fig. 4 is a speed curve plotted according to the speeds shown in Fig. 3; and a diagram of the spindle drive is also shown at the left-hand side of Fig. 4. Table I shows available surface speeds in feet per minute on bar stock of ½ to 2½ inches diameter. The enormous range of surface speeds obtainable on one size of machine, such as is here shown, will be readily appreciated. Fig. 5 is a diagram of the cam drum *B*, Fig. 2. This drum is graduated into five different spaces which are numbered from 1 to 5, as indicated. These spaces on the cam drum correspond to the numbers of the tool holes in the turret of the machine, so that in setting up the operator can tell at a glance the relative position on the cam drum which would give the desired spindle speed at the time any one of the turret tools came into operation. In the illustration accompanying Table II is shown a piece made from 2-inch hexagon cold-rolled steel, finished complete as shown on this machine; the total time was three minutes, forty-five seconds. Another piece is shown at *B* made from 1½-inch square cold-rolled steel. The time for making this piece was one minute, forty-five seconds; and the operations on this piece were as shown in the table.

TABLE I. AVAILABLE SURFACE SPEEDS IN FEET PER MINUTE

Diameter of Stock, Inches	Speed of Spindle in Revolutions per Minute for Controller Positions															
	50	57	69	80	93	109	127	149	171	199	232	271	315	368	429	500
½	....	....	....	....	....	14.3	16.5	19.5	22.4	26.1	30.4	35.5	41.5	48.2	56.3	65.5
1	....	14.9	18.1	21.0	24.4	28.5	33.3	39.0	44.8	52.2	60.8	71.0	82.8	96.5	112.5	131.0
1½	19.6	22.4	27.2	31.4	36.4	42.9	49.9	58.6	67.2	78.3	91.3	106.6	124.2	144.6	168.9	196.5
2	26.2	29.9	36.2	42.0	47.2	57.1	66.5	78.2	89.6	104.2	121.5	142.0	165.5	193.0	225.0	262.0
2½	32.7	37.3	45.2	52.4	60.9	71.5	83.2	97.5	112.0	130.5	152.0	177.5	207.0	241.0	281.0	328.0

Machinery

NOTE: Method of selecting spindle speed which should be used to obtain surface speed in feet per minute for any diameter required.

$$\text{R.P.M.} = \frac{S \times 3.819}{D}.$$ S = surface speed in feet per minute. D = diameter of stock.

Referring to Fig. 1, it will be noted that this machine is so designed that the electrical apparatus is out of the operator's way, and also that it cannot be damaged by the large quantity of oil and chips which are always closely associated with the operation of automatic machines. The push-button *A*, Fig. 1, which entirely controls the starting and stopping of the machine, is in a convenient location and is of a type which is indestructible. All the electric wiring is enclosed in conduits, part of which are flexible in order to allow of adjustment of the position of the motors to obtain the correct tension on the silent driving chains.

With this machine an operator has adjustable spindle speeds and also adjustable feeds for all tools, without the necessity of making any special cams for any work within the range of the machine. There is nothing difficult about making any of the cam adjustments, and all cams are readily accessible. This is one of the great points of the Cleveland automatic, making it possible to change over quickly and easily from one job to another, and always be sure of obtaining the correct speeds needed for every tooling operation, whether the lots to be run out are small or large.

Notes on Tooling

When using a forming tool on the cross-slide a very high rate of peripheral speed may be used while hogging off the stock, and when almost down to size the speed and feed may be momentarily lowered, which will have the effect of producing a smooth forming cut. In the case of forming into square or hexagon stock, a slow spindle speed may be used while the corners of the stock are being removed by the forming tool, and when the tool gets past the flats on the stock the peripheral speed can be increased to any extent desired. The possibility of so regulating the spindle speed for certain conditions is of great value. In threading with a tap or die, a very low peripheral speed and powerful drive is instantly available, and at the end of the threading operation the spindle may be reversed at high speed to back off the tap or die quickly. The line voltage may vary ± 20 per cent without in any manner affecting the relative speed necessary between

Fig. 4. Spindle Speed Curves and Diagram showing Arrangement of Geared Drive

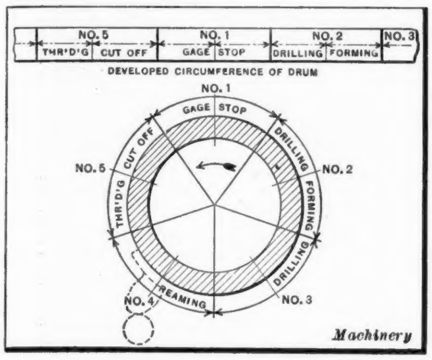


Fig. 5. Divisions on Controller Drum, showing Positions of Tools and Cross-section through Drum

the threading tool, which is controlled by the small pilot motor, and the spindle, which is controlled by the large variable-speed motor. This is accomplished by means of a special adjustment of the electrical apparatus.

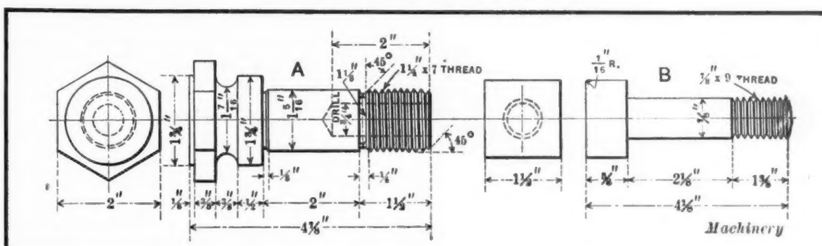
For drilling operations, excellent results are obtained with this machine on account of the fact that, regardless of the diameter of the drill, a speed may always be picked out that will be just right. Similarly, for removing stock with a box-tool, an enormous gain in time is made by using a very high peripheral speed. The same holds good with reaming operations. In any case, a speed may always be selected to suit the kind of material or the amount of stock desired to be removed and still produce a fine finish.

For operations such as cross-drilling, the spindle may be instantly stopped dead and held there for any desired length of time. On account of the ease with which the spindle may be stopped and started at any moment, it is stopped for feeding the bar through to the gage stop when desired.

The cutting-off operation, which usually consumes much time and is to a great extent a source of trouble, is accomplished with ease and quickness on this machine, and a good job is always obtained. The reason for this is that the peripheral speed at the point of the cutting tool is held practically constant at all times. This is accomplished by throwing in one speed after another as the cut-off tool approaches the center of the work, increasing the spindle speed step by step until the work is cut off. By this means the cutting off can be accomplished very much more quickly than is possible when the spindle speed is held constant during the entire cutting-off operation. The machine may be equipped with motors for either 110- or 220-volt direct current.

This combination of an adjustable speed control which enables the speed to be varied during the performance of any one operation or between successive operations, makes an unusually efficient means of handling automatic screw machine work when combined with the adjustable feed control which is a regular feature of all Cleveland automatics. As most readers of MACHINERY know, the rate of feed on these machines is governed by cams on a feed control drum, two of these cams being provided for each tool on the machine. By making a suitable setting of the cams, the rate of feed may be made uniform for the entire operation performed by a given tool or the cams may be set at different angles on the drum in order to obtain a change of feed during the performance of the operation. Combining the automatic adjustable speed control with this feed control has provided an equipment particularly well suited for handling all classes of work.

TABLE II. EXAMPLES OF WORK FOR WHICH SPEED VARIATION IS PARTICULARLY BENEFICIAL AND OPERATIONS INVOLVED IN PRODUCING PIECE B



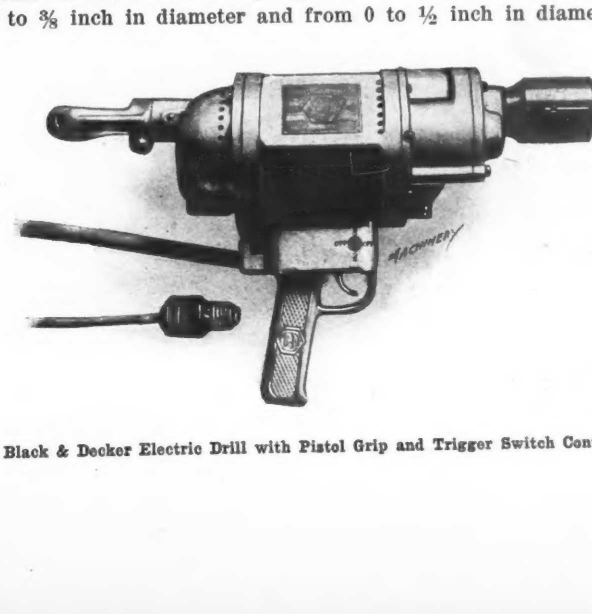
Operation	Time in Seconds	Revolutions per Minute	Feed, Inch per Revolution	Surface Speed, Feet per Minute	Amperes at 110 Volts
Milling	60	308	0.012	0.120	28
Forming	Formed during milling	190–308	0.006	60–160	32
Threading	12	90	.....	21	8
Cutting off	14	308–500	0.006	120	28
Idle movement	19	......	.....	......	4
Total	1 minute 45 seconds				

BLACK & DECKER ELECTRIC DRILL

The important feature of a portable electric drill which is now being made by the Black & Decker Mfg. Co., Baltimore, Md., is the provision of a pistol grip and trigger switch control, which is said to greatly reduce the liability of breaking small drills. On this tool, the switch is operated by the index finger of one hand without requiring the grip on the handle to be released; as a result, the operator is able to maintain a steady "aim" at all times, and when the drill breaks through he can cut off the power without the slightest wavering of the tool or sagging of the weight which is likely to cause a small drill to break. Furthermore, the drill is so shaped and the weight distributed with relation to the position of the grip, that the tool is easy to handle and control. The tool is also made as light as possible, still maintaining the necessary amount of strength and rigidity.

The housings are cast from aluminum alloy, and gears are cut from solid blanks of chrome-vanadium steel and heat-treated to give them long life and freedom from breakage while in service. The chuck spindle is hardened and ground, and runs in a bronze bushing, the end thrust being taken care of by a ball thrust bearing. The motor is of the so-called universal type, adapted for use on either alternating- or direct-current circuits, and 110- or 220-volt motors can be supplied, according to the requirements of the user. A forced draft ventilating system provides for carrying a considerable overload without damage to the windings; and the spindle is ground to size and runs in Norma ball bearings.

The commutator and brushes are readily accessible by removing four screws which enable the top of the cover to be slipped off. The cover does not carry the armature shaft bearing, this bearing and the brushes being carried by an inner spider which is protected from external injury or strain. If so desired, the drill may run while the cover is removed to enable the operation of the brushes and commutator to be inspected. When so desired, a breast plate can be furnished for use in place of the rear grip. It was previously stated that these drills are equipped with motors for use on either 110- or 220-volt circuits; and drills with these styles of motors are made in two sizes having capacities for drilling holes from 0 to ⅜ inch in diameter and from 0 to ½ inch in diameter.



Black & Decker Electric Drill with Pistol Grip and Trigger Switch Control

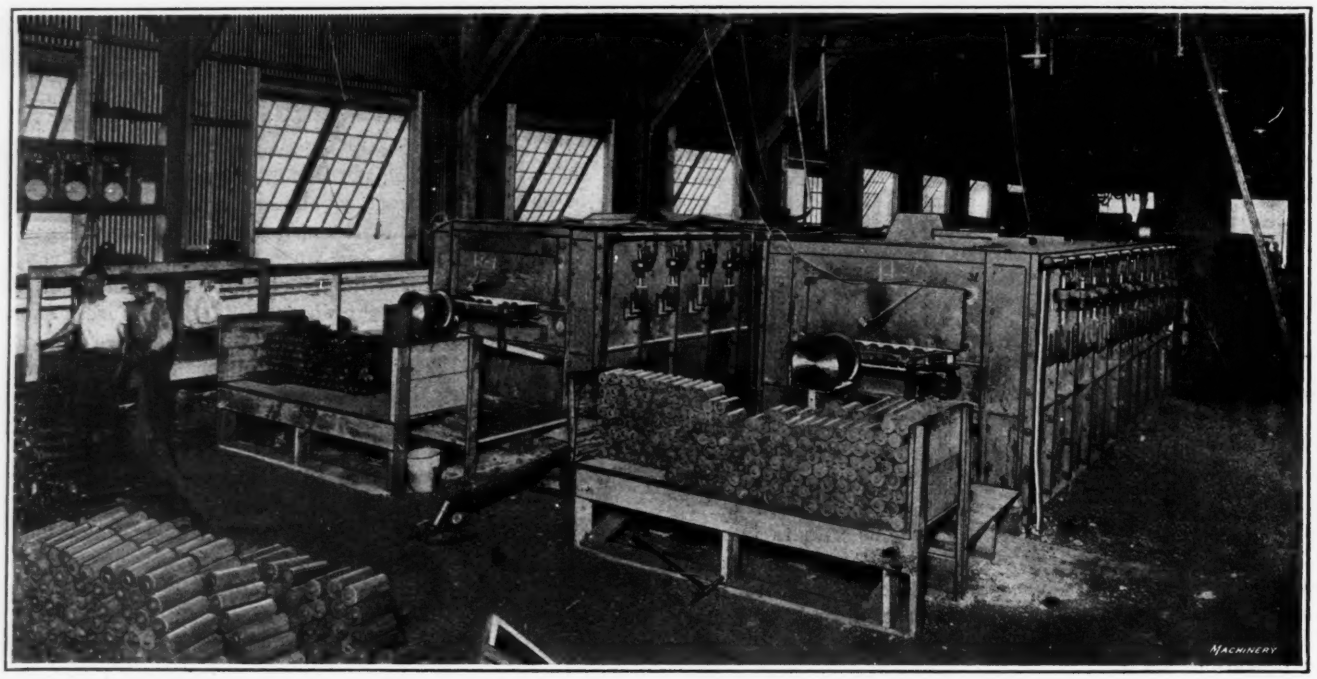


Fig. 1. Charging End of Hardening Furnaces with Pushers in Place. One Tempering Furnace can be seen at Extreme Right, with Oil Quenching Tank at Front. Control Pulpit is shown at Left of Hardening Furnaces

SURFACE COMBUSTION SHELL HEAT-TREATING FURNACES

These furnaces are used for hardening and tempering shells. They are fired by the Surface Combustion Co.'s high-pressure system, in which gas at a pressure of 25 pounds per square inch is made to inspirate the required amount of air for its complete combustion. The furnaces are arranged in units consisting of one hardening and one tempering furnace, and each unit has a capacity for heat-treating 5000 shells in twenty-four hours. Each unit consumes 3300 cubic feet of gas per hour, and the remarkably high efficiency of 32 per cent is obtained, this efficiency representing the percentage ratio of the heat actually absorbed by the work to the total amount of heat in the fuel. It is possible to arrange the inspirator so that complete combustion is obtained, but in order to prevent scaling the work and burning out the feed chutes of the furnaces, it is found advisable to operate them with a slightly reducing atmosphere—carbon monoxide being present to the extent of from 0.3 to 0.5 per cent.

For use in heat-treating shells in the plant of the Eddystone Ammunition Corporation, Eddystone, Pa., the Surface Combustion Co., Wilbur Ave. near Sunswick St., Long Island City, N. Y., has designed and installed the furnaces illustrated and described herewith. The installation consists of three hardening and three tempering furnaces, one hardening and one tempering furnace being under construction at the present time, while two furnaces of each type are in operation. Each furnace is approximately 22 feet long by 8 feet wide by 7 feet high, and they are arranged in units consisting of one hardening and one tempering furnace. Each unit is designed to turn out 5000 shells in a twenty-hour working day, so that full capacity from the installation of three units would be 15,000 shells in twenty hours.

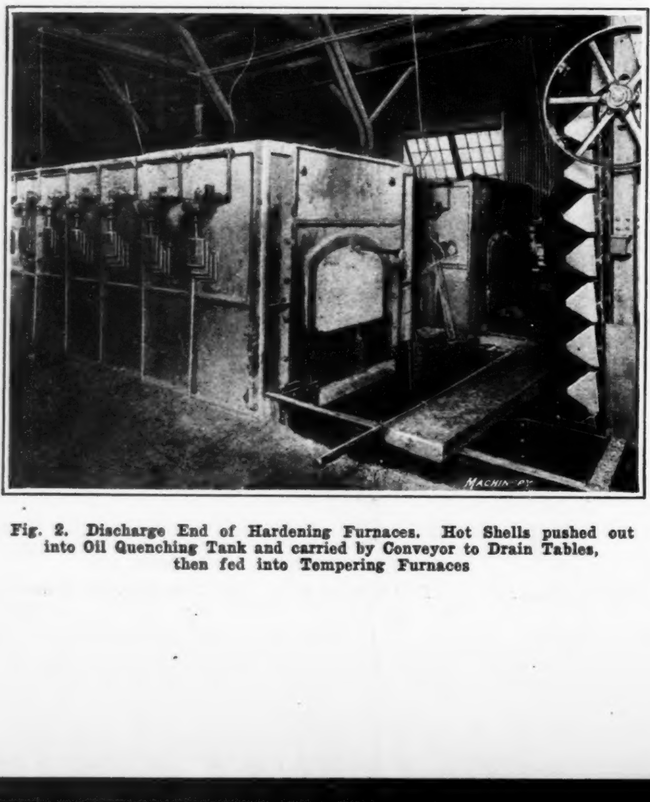


Fig. 2. Discharge End of Hardening Furnaces. Hot Shells pushed out into Oil Quenching Tank and carried by Conveyor to Drain Tables, then fed into Tempering Furnaces

The furnaces are fired by the Surface Combustion Co.'s high-pressure system, a process or system whereby gas under pressure is made to inspirate all the air necessary for complete and perfect combustion, maintaining automatically constant-mixture proportions and eliminating all motors, blowers and air piping. It is a one-pipe system, and is capable of very accurate control from a central control pulpit. Added to these advantages are the features of surface combustion proper. 580 B. T. U. gas (a mixture of water and coal gas) is supplied by the Philadelphia Suburban Gas & Electric Co. of Chester, Pa. This gas is delivered and metered under a pressure of 25 pounds per square inch. The gas is metered by a rotary pressure meter and a Bailey flow meter. The furnaces are operating at an average efficiency of 32 per cent—a remarkable furnace efficiency. Furnace efficiency means the percentage of available heat units in the fuel consumed which are actually absorbed by the work being done, in this case heating steel.

Each unit (one hardening and one tempering furnace) consumes an average of 3300 cubic feet of gas per hour, turning out 240 shells per hour. Therefore when all these units are running at capacity, 9900 cubic feet of gas per hour is consumed, and for a day of twenty-four hours, 237,000 cubic feet of gas, and for 300 such days approximately 71,000,000 cubic feet of gas. While shells are only turned out during twenty hours, the furnaces are kept hot the entire twenty-four hours. Cost of gas in this case is based on a sliding scale rate. The approximate average rate for this work is forty-three cents per thousand cubic feet. The hardening is done at an average temperature of 1500 degrees F. and the tempering (or drawing) at an average of 1100 degrees F. Each shell is in each furnace for a period of approximately one hour. The shells are 3 inches in diameter, and are approximately 8½ inches long; they vary in weight from 8 to 11 pounds.

Running through each furnace are eight steel angles which act as troughs to carry the shells. An air cylinder with an arm attached to the piston rod acts as a pusher; and a man stands in front of the furnace and feeds shells into the angle troughs. Every two minutes the pusher pushes the shells ahead the length of a shell. This causes eight shells to discharge into the oil quenching bath located at the discharge

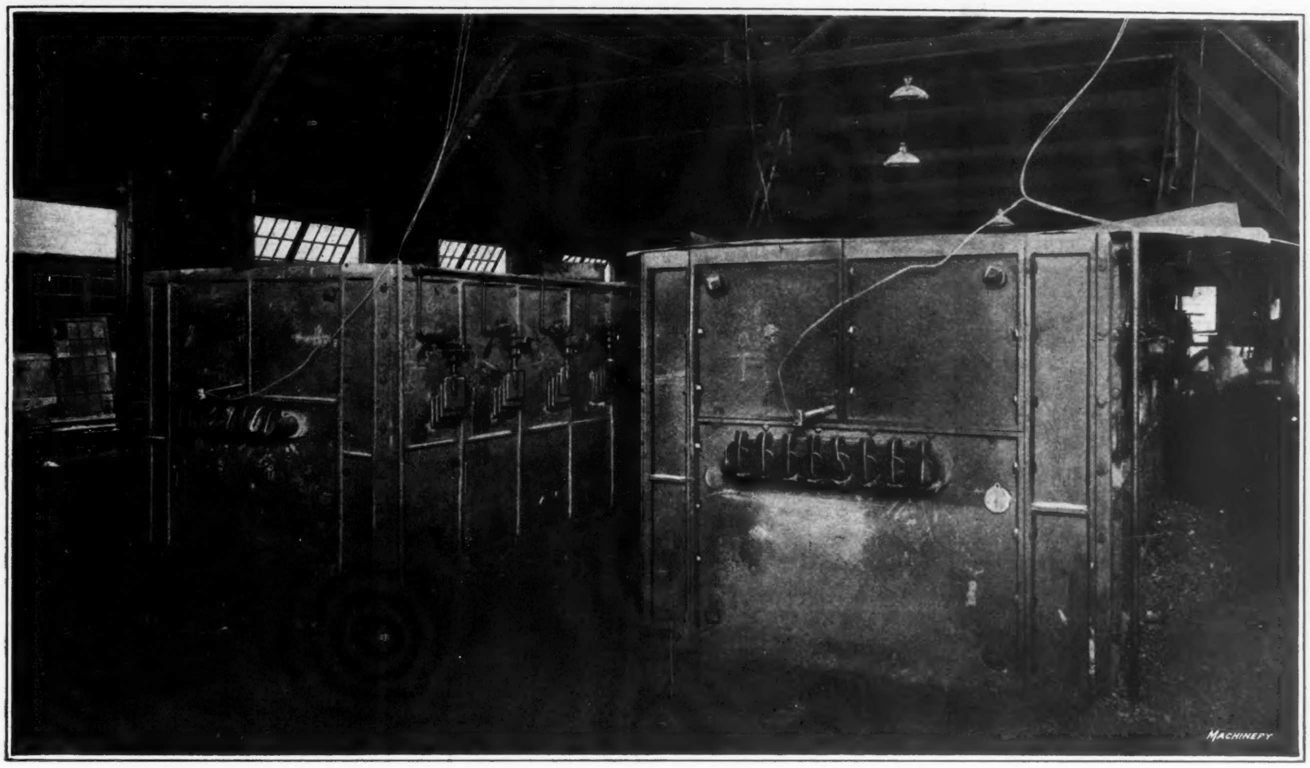


Fig. 3. Discharge End of Tempering Furnace. Shells are pushed out through Tubes which have Hinged Covers to exclude Air, shown at Front of Furnaces

end of the hardening furnaces, from which they are taken when sufficiently cool and fed into the tempering furnaces in exactly the same manner. The furnaces are on a slight slope.

All the furnaces are controlled from a central control pulpit. Each furnace is controlled by a single valve which regulates the pressure supplied, the maximum pressure being 25 pounds per square inch and the minimum 5 pounds per square inch. The average operating pressure is 15 pounds per square inch. All pyrometers, both indicating and recording, are also located in this pulpit, which allows one man to easily operate all the furnaces. This feature also allows much more accurate and careful control, as evidenced by the practically straight line pyrometer charts which are secured daily. There is also located in this pulpit the electric "flasher," which times the charging operation. This machine flashes a red light in front of each furnace every two minutes, which is the signal for the men to operate the pushers. The furnace operator in the control pulpit, each shift, receives his temperature and time instructions, and is able to follow these instructions with the greatest accuracy without moving a step. This pulpit is the "brains" and heart of the heat-treating building, clock, bells, etc., all being located there.

The furnaces are encased in cast-iron casings, tied together by heavy tie-rods and mounted on concrete foundations. The heavy firebrick linings are backed up by "Sil-O-Cel," giving plenty of insulation. This cuts down the radiation losses and protects the operators from the heat. In hot weather this is a point which is greatly appreciated by them. The furnaces are made as air-tight as possible, and to prevent cold air leaking in, which would produce an oxidizing effect and by its cooling action lower the furnace efficiency, a slight furnace back pressure is maintained. The furnaces are so designed as to develop and utilize the maximum amount of radiant heat. The flues are arranged so as to distribute the hot gases uniformly and to release them at the lowest possible temperature. The hardening furnaces are equipped with twenty-two high-pressure burners, and the tempering furnaces with eighteen burners. All piping is laid in conduits having removable covers, thereby eliminating all overhead work. To give an idea of the simplicity of the system, the largest pipe used is a 2-inch size. Each burner is fed by a ½-inch pipe from a 1-inch manifold.

Frequent flue gas analysis has shown oxygen = 0.0, carbon monoxide = 0.0, and an average of 15.2 carbon dioxide. This shows that the heat is generated with 100 per cent efficiency, having no excess air or unburned gases. For the purpose of minimizing the scaling of the shells and to lengthen the life of the angle troughs, the furnace is operated with a slightly reducing atmosphere—carbon monoxide reading between 0.3 and 0.5 per cent. This is done to be on the safe side, as an oxidizing atmosphere would be very injurious in this operation. The "surface combustion" principle was described in the May, 1915, number of MACHINERY in an article entitled "Surface Combustion Appliances."

"ROULSTED" ENGINE LATHE

The "Roulsted" 20-inch engine lathe illustrated and described herewith is built by the Waterville Iron Works, Waterville, Me.; and Hill, Clarke & Co., Inc., 156 Oliver St., Boston, Mass., have the sales agency for this machine. The lathe is equipped with a three-step cone pulley and double back-gears, and it has a semi-quick-change gear-box. Figs. 1 and 2 show a lathe equipped with a compound rest and with a turret toolpost, respectively; either of these equipments may be furnished according to the requirements of the shop in which the lathe is to be used.

The bed is cross-webbed at intervals of 2 feet and the ways are of the V-type. The headstock is bolted to the bed in a

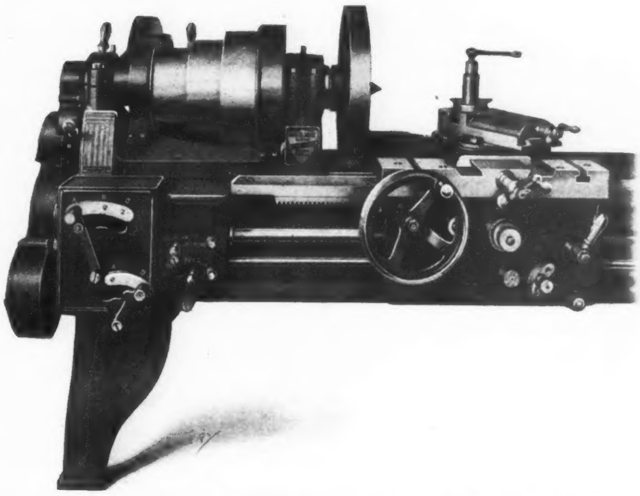


Fig. 1. "Roulsted" Engine Lathe equipped with Compound Rest

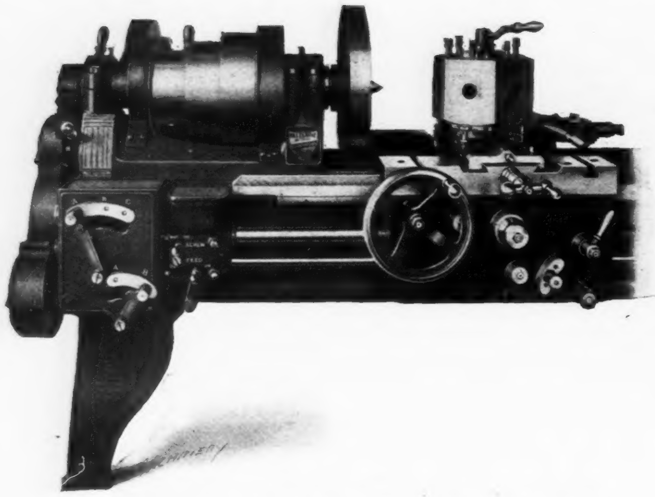


Fig. 2. "Roulsted" Engine Lathe equipped with Turret Toolpost

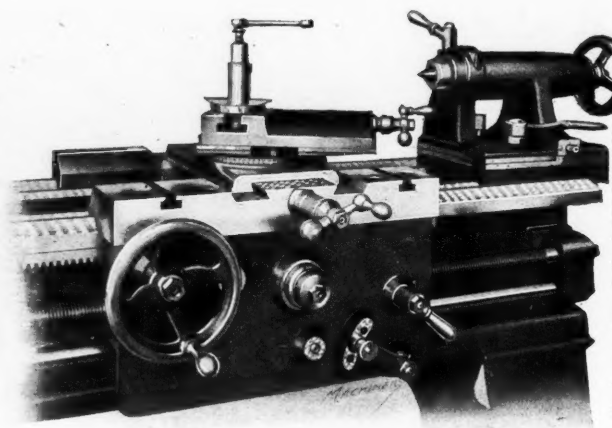


Fig. 3. Tailstock End of "Roulsted" Engine Lathe

way which secures absolute rigidity; and the hollow spindle is made of high-carbon crucible steel, forged and heat-treated, with the hole bored from the solid metal and reamed to size. The outside of the spindle is turned and ground, and the spindle is carried in bronze bearings which are scraped and fitted to both the headstock and spindle. End thrust is supported by a fiber washer, and the spindle is secured against end play by an adjusting nut at the end, which is also used in making compensation for wear. This construction maintains a positive position of the spindle under the heaviest service. An all-steel tumbler gear reverse is provided in the headstock for cutting left-hand threads or for changing the feed; and all gears are thoroughly guarded to avoid accidents to operators or damage to the gearing.

The carriage has a full length bearing on the vees and is gibbed front and back, and provided with a locking screw. The cross vees and bridge are wide and heavy, and the compound rest is graduated in degrees and securely gibbed. The apron is of the double-plate type which provides ample bearings at both ends of all shafts; it is firmly bolted and doweled to the carriage. All pinion shafts are made of steel and are integral with the gears, which are cut from solid blanks. A locking device is provided which makes it impossible to engage the feed-rod and lead-screw at the same time. An apron reverse is provided for all feeds which may be operated independently of the reverse screw in the headstock. The carriage has friction feed and the cross-feed screw is graduated to read to 0.001 inch.

The tailstock usually furnished with the lathe provides for setting the compound rest at right angles when the carriage and tailstock are used close together on the bed. The spindle and screw are accurately fitted, and the tailstock can be set over and clamped to the bed in any position for taper turning operations. The semi-quick-change gear-box has all steel gears which afford a wide range of feed; and special means are provided for disconnecting the lead-screw and feed-rod from the gear-box while the lathe is running. Change-gears are provided to enable either extra fine or coarse thread or rates of speeds to be obtained. Regular equipment furnished with the machine includes a two-speed double friction countershaft, although a one-speed countershaft with a high-speed reverse may also be employed with satisfactory results; in addition, the standard equipment includes a full set of change-gears, large and small faceplates, toolpost ring and wedge, steadyrest and wrenches.

The principal dimensions of this lathe are as follows: swing over bed, 21 inches; swing over carriage, 14 inches; swing over steadyrest, 8 inches; capacity between centers for 8-foot bed, 3 feet, 9 inches; diameter of hole through spindle, 2 1/16 inches; width of driving belt, 4 inches; ratio of double back-gears, 10 to 1 and 3½ to 1; available spindle speeds, 7 to 285 revolutions per minute; available gear feed, 6 to 90 per inch; available range of threads which may be cut, 2 to 30 per inch, including 4½ and 11½ threads per inch; maximum travel of compound rest, 5½ inches; diameter of tailstock spindle, 2⅞ inches; travel of tailstock spindle, 8 inches; size of tools used, ⅞ by 1½ inch; weight of machine with 8-foot bed, 4100 pounds; and weight per additional foot of bed, 230 pounds.

PUTNAM ENGINE LATHE

The 22-inch engine lathe illustrated and described herewith is a recent product of the Putnam Machine Co., Fitchburg, Mass.; and Manning, Maxwell & Moore, Inc., 119 W. 40th St., New York City, are the sales agents. It will be apparent from the illustrations that this machine is equipped with a standard carriage and compound rest, tailstock and steadyrest; or that a turret may be provided on the carriage. In other respects, the two machines are identical.

The machines are driven by a three-step cone pulley and double back-gears; and they have universal feed, *i. e.*, gear, screw and belt feed combined, operated instantaneously without the necessity of removing the feed belt or changing gears. The spindle is made of forged open-hearth steel, and is supported in bearings provided with self-oiling bronze boxes which maintain the precision of the spindle and faceplate, and help to preserve true alignment of the live and dead centers. The lead-screw is made of special steel and great care is taken to obtain a high degree of accuracy in cutting the thread. The feed rack is made from a forged steel bar and is securely anchored to the bed; it is 1⅛ inch face width and the teeth are 0.524 inch pitch.

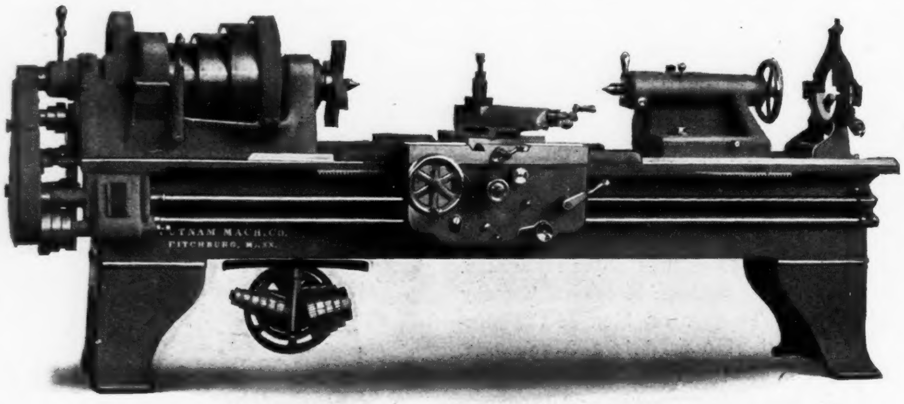


Fig. 1. Putnam 22-inch Engine Lathe with Compound Rest, Tailstock and Back Rest

The tailstock has a liberal bearing on the ways and is held in alignment with the head by a vee at the rear of the bed, the front bearing being flat. The joint between the tailstock base and top is accurately scraped and a wide tongue is

fitted into a groove in the tailstock base to keep the spindle in perfect alignment with the head spindle. Provision for setting over the tailstock is made by means of a screw and nut. The carriage has bearings 30½ inches long on the outside raised ways, in addition to which it has a bearing on the front inside flat way. All bearing surfaces are scraped to a perfect fit, and the carriage is gibbed both front and rear. The compound rest is fitted with a tool-block for carrying tools ⅞ by 1¼ inch in size. The apron is an improved design provided with large, powerful friction for lateral feed and an eccentric stud gear for cross feed. An automatic safety device is provided, making it impossible to engage the lead-screw and feed-rod at the same time. All feeds are reversed and controlled at the apron. The screw nut is lined with babbitt and is 5¾ inches long; it is operated by a cam plate. The range for screw cutting through individual change-gears is from 1 to 16 threads per inch.

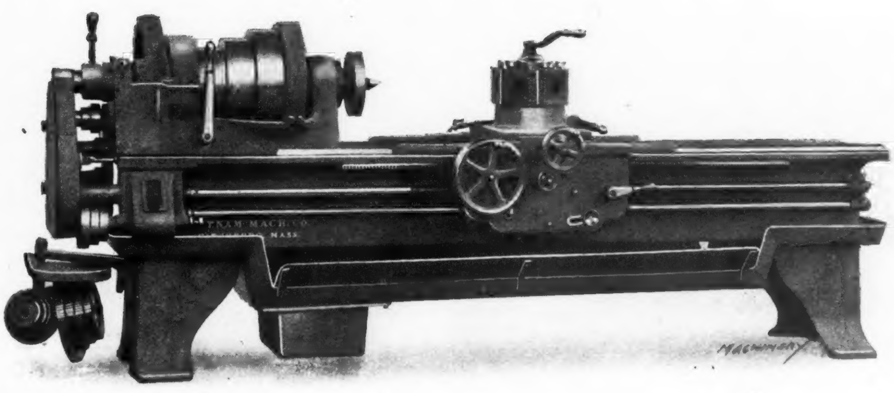


Fig. 2. Putnam 22-inch Lathe with Heavy Turret on Special Carriage

The regular equipment furnished with the machine includes one set of tool steel centers, a dog faceplate fitted to the nose of the spindle, a large standard circular faceplate, an adjustable three-jaw back rest, a countershaft with two friction pulleys and wrenches. The swing over the ways is 22½ inches; swing over carriage, 13¾ inches; swing over compound rest, 13¾ inches; distance between centers for 10-foot bed, 5 feet; cone pulley diameters, 11, 14 and 17 inches by 4¼ inches face width; available spindle speeds, 7, 10.8, 16.8, 25.4, 39.3, 60.8, 90.5, 140 and 216 revolutions per minute; size of front spindle bearing, 4⅛ by 8⅛ inches; size of rear spindle bearing, 3 by 5⅛ inches; diameter of tailstock spindle, 2 15/16 inches; and weight of machine with 7-foot bed, 4100 pounds.

BRIDGEFORD PLAIN TURNING MACHINE

The 27-inch by-12-foot plain turning machine illustrated and described herewith is a recent product of the Bridgeford Machine Tool Works, 235 Mill St., Rochester, N. Y. The machine takes 6 feet between centers, and swings 13½ inches over the carriage and 27 inches over the ways. Three instantaneous changes of spindle speeds are obtained through sliding hardened steel gears, and four instantaneous changes of feed through cut steel gears. The main driving gear is 6½ inches face width. Both the speed and feed change-gears run in oil. All main bearings on the machine are lined with bronze and are self-oiling; the front spindle bearing is 6 by 9 inches in size; and the rear spindle bearing, 5 by 7½ inches.

This lathe is especially adapted for performing the outside turning operation on 8-, 9.2- and 12-inch shells, and it will be seen that two carriages are provided. The carriage nearest the headstock is used for turning the straight wall of the shell, while the one at the tailstock end is used for forming the nose, this carriage being run in conjunction with a radius attachment which is shown in the back view of the machine, Fig. 2. A hollow spindle is provided so that an air chuck may be easily attached; and the machine has ample strength to safely transmit thirty horsepower. On a speed test in turning 8-inch shells, one user of this machine rough-turned a shell of this size in 4½ minutes. The weight of the machine is 15,000 pounds.

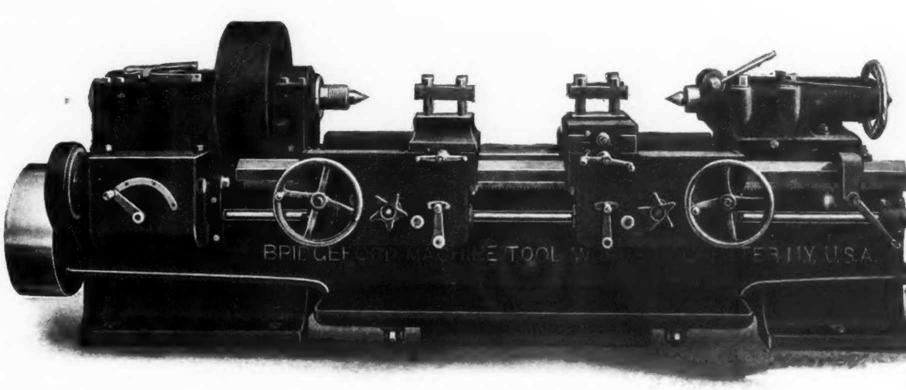


Fig. 1. Front View of Bridgeford 27-inch Plain Turning Machine

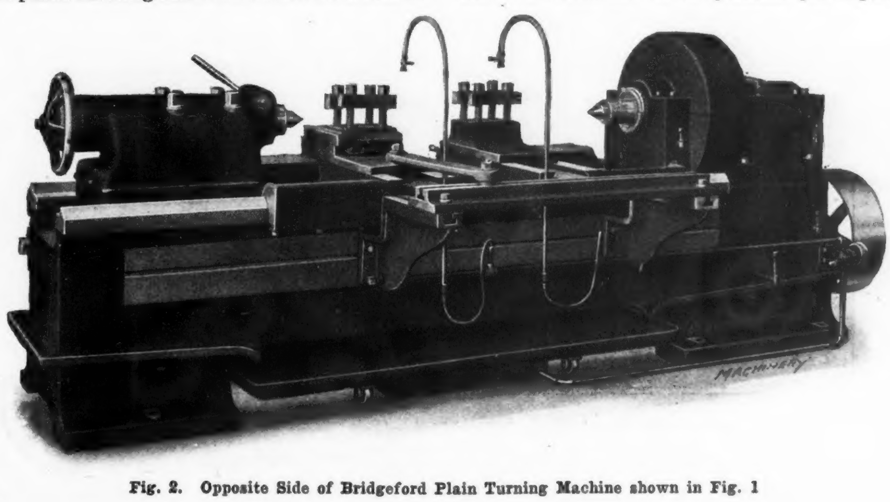


Fig. 2. Opposite Side of Bridgeford Plain Turning Machine shown in Fig. 1

"SPRACO" PAINT GUN

The "Spraco" paint gun recently placed on the market by the Spray Engineering Co., 93 Federal St., Boston, Mass., is a hand tool for use in applying all kinds of liquid protective coatings to various classes of work. The complete equipment consists of the paint gun proper, which is connected by a flexible hose to a portable unit containing the paint tank, air dryer and strainer, pressure control attachment and pressure gage. After the portable control head has been adjusted to meet the conditions of air pressure, thickness of paint, etc., the operator has complete control of the outfit by means of a trigger on the paint gun. The unit is furnished complete, ready for attachment by a single hose connection to the compressed air supply which should have a pressure of from 35 to 75 pounds per square inch, according to the nature of the paint used and the degree of finish desired. The equipment is adapted for use in shops or in the field, and may be adjusted for spraying the higher grades of varnish or lacquer as well as heavy asphaltum and structural paints, producing finely finished surfaces without streaks.

Fig. 1. Complete Portable Outfit for Use with "Spraco" Paint Gun for spraying Paint

There are but two adjustments required in operating the "Spraco" gun, *i. e.*, the round cap at the nose which screws out or in to regulate the amount of paint delivered by the gun, and the knurled stem at the rear which screws out or in to control the amount of air that is used. These adjustments only have to be made once to regulate the proportion of air and paint required for any class of work; then the control trigger acts on both the air and paint, regulating the amount of paint delivered from zero up to the full amount for which the adjustment has been set.

The control head is an important feature of the apparatus, and consists of a complete unit comprising the following parts: (1) A pressure gage showing the air pressure on the main supply line, and also on the paint in the tank. (2) An adjustable reducing valve by which pressure on the paint may be varied at will so that the action of the gun is made independent of the position of the tank, and any form of paint or other material may be fed to the gun at suitable pressure; this adjustable reducing valve also permits of using any pressure less than the main line pressure, which is essential where very high air supply pressures are maintained. (3) A complete air strainer and filter by which a supply of dry, clean air may be obtained; and this filter may be readily inspected and cleaned without the use of tools. The complete control unit is especially designed for use with the standard portable equipment. It may be used separately when connection is made with a paint barrel, tank or other container.

The pressure tank is designed to withstand full air pressure if necessary, and is made of galvanized iron riveted together. A filling plug in the base permits of filling or emptying the tank without disturbing the control head. Connection with the air system is made by a rubber hose provided with a heavy braid covering, while a flexible metal hose is commonly employed for delivering the paint supply to the gun. Special forms of this hose can be provided if required. Where paint or other materials which do not injure rubber are used, a hose similar to the air hose will be found satisfactory. For shop use the control head and pressure regulator are non-essential, unless very heavy paint is being used; and under such condition the gun may be connected directly to the air pressure line, using an air regulator if the supply pressure is excessive or if the air is not dry and clean. The paint is placed in a tank suspended above the work and is supplied to the gun by gravity. A suitable paint tank with block and tackle for suspension can be furnished with the gun if so desired. The air regulator may be supplied with a filter, pressure gage and reducing valve, providing a complete air controlling apparatus in a single unit.

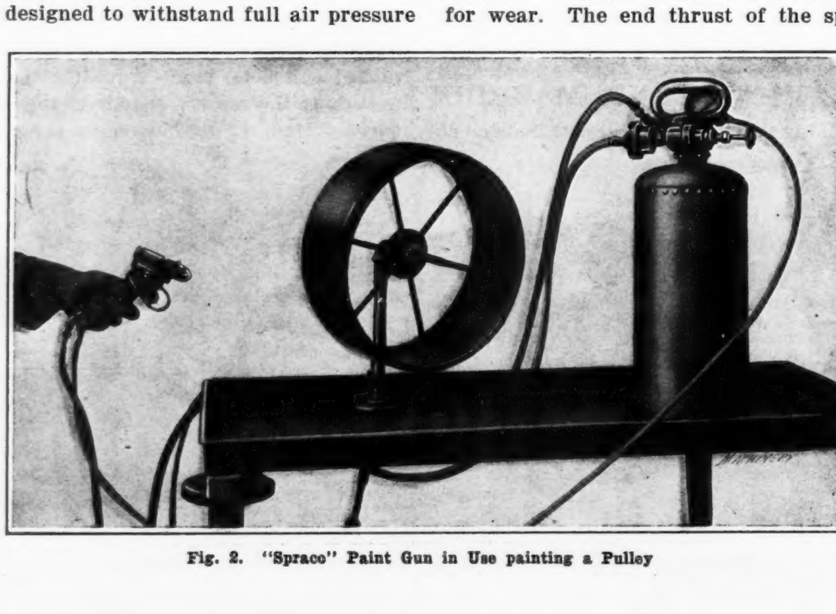
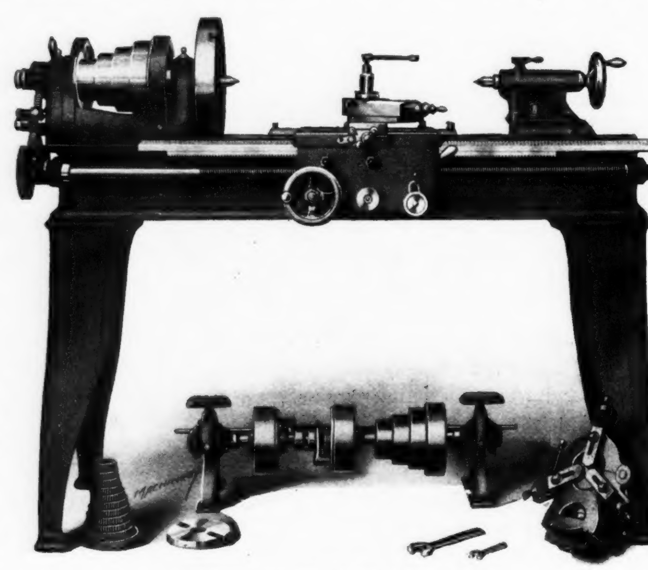


Fig. 2. "Spraco" Paint Gun in Use painting a Pulley

Advantages claimed for this apparatus are that the time required to paint work is reduced from 50 to 75 per cent; that the gun makes it possible to reach surfaces that could not otherwise be thoroughly covered; that it is easily operated and adjusted without the use of tools and is free from delicate parts; that the design is simple and the construction sufficiently rugged to withstand hard service; and that the total weight of the gun is only a little over one pound.

VERNON 11-INCH LATHE

The Vernon Machine Co., Inc., Worcester, Mass., is now building the 11-inch lathe shown in the accompanying illustration.



Vernon Machine Co.'s 11-inch Lathe

The machine is driven by a four-step cone pulley and single back-gears, thus providing eight changes of spindle speed. The spindle is made of high-carbon steel and finished to size by grinding; it is carried in bronze-lined bearings which have ample oiling facilities and means of compensation for wear. The end thrust of the spindle is supported by a step bolted to the end of the headstock. The tailstock is of the offset type which allows the compound rest to be set parallel to the bed; in addition, the tailstock can be set off center to provide for the performance of taper turning operations.

The carriage has a very stiff bridge and long bearings on the vees; it is securely gibbed to the bed and the compound rest is adequately supported by it. The apron is

bolted to the carriage and all gears in the apron are liberally proportioned for the loads they are required to carry. Positive geared feed is supplied with each lathe and the number of changes that are available is limited only by the number of change-gears obtained for use with the lathe. The regular equipment furnished with each machine includes large and small faceplates, center- and follow-rests, a countershaft and the necessary wrenches for making all adjustments.

The principal dimensions are as follows: diameter of hole through spindle, 7/8 inch; swing over ways, 12 1/8 inches; swing over compound rest, 7 1/2 inches; distance between centers for 5-foot bed, 33 inches; change-gears provided for cutting 4 to 36 threads per inch; width of driving belt, 1 3/4 inch; and weight of machine with 5-foot bed, 775 pounds.

LANGELIER MOTOR VALVE SLEEVE MULTIPLE DRILLING MACHINE

For use in drilling at one operation the twelve 1/8-inch oil holes in the outer sleeve of a Willys-Overland motor valve, the Langelier Mfg. Co., Providence, R. I., designed the multi-

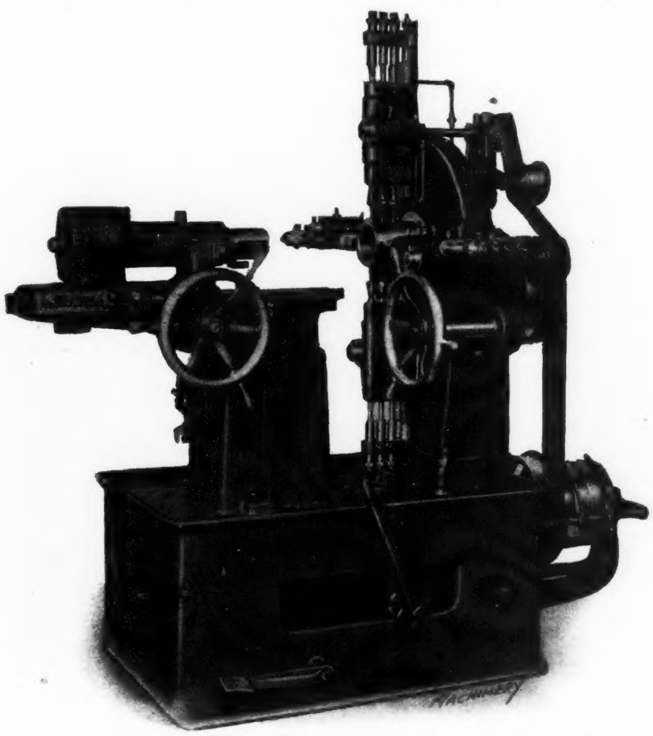


Fig. 1. Langelier Multiple-spindle Machine for drilling Motor Valve Sleeves

ple drilling machine which is illustrated and described herewith. A similar machine was built for use in drilling four 1/8-inch holes in the inner sleeve, and the output of each machine is 3 1/2 sleeves per minute, or 2100 per day. The machines are of exactly the same design except that one is equipped with twelve drill spindles while the other has only four spindles.

Fig. 3 shows a cross-sectional view through the drill jig on the machine for drilling the outer sleeve, in which the work is shown in the drilling position. Referring to this illustration in connection with the following description, the method of operating

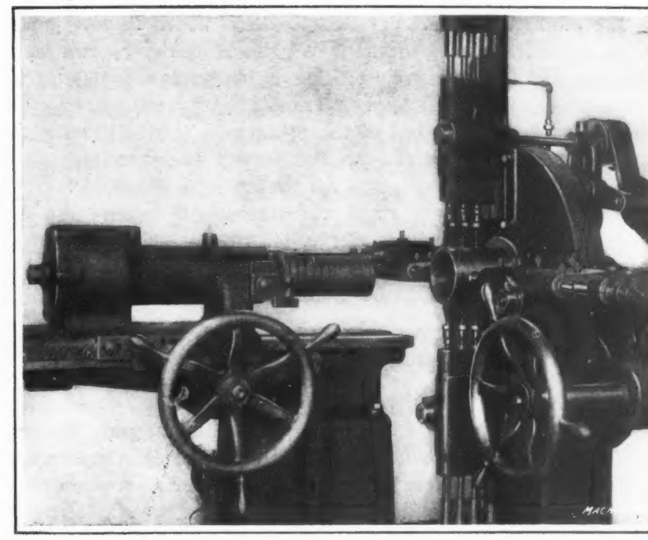


Fig. 2. Close View of Mechanism with Drilled Sleeve on Arbor after being withdrawn from Jig

the machine will be clearly understood. Sleeve *A* is held and located in the drilling position by an internal expanding arbor *B* mounted on tailstock *C* which slides upon ways in line with the axis of the machine. Expanding arbor *B* is opened or closed automatically by means of compressed air; the construction consists of a split sleeve that is attached directly to the piston in the compressed air cylinder; and inside this sleeve there is a fixed arbor *D* with a tapered end, that is attached to the cylinder head. A slight travel of the sleeve on this tapered portion of the fixed arbor causes the sleeve to expand and hold the work securely, extra movement being avoided by a stop collar on the sleeve and tapered arbor.

Admission of air to the cylinder is controlled by a small piston valve that is attached to the tailstock *C* at the rear and operated by contact with a fixed stop attached to the tailstock slide. The tailstock is shown in its outer or loading position in Fig. 1, movement of the tailstock slide being secured by means of the handwheel at the front of the machine. The drilling position is obtained by the sleeve to be drilled coming into contact with a stop *E* located inside drill jig *F*; this stop can be adjusted at the left-hand end of the machine. The tailstock is also automatically locked when in a drilling position and is unlocked by the foot-treadle shown at the front of the bed; this lock is adjustable and can be set to suit the requirements of the work being drilled.

Drilling heads *G* are located radially 90 degrees apart upon a circular faceplate *H* that is mounted on column *J* attached to the bed of the machine. Drilling spindles *K* are driven by spiral gears, the drivers extending to the rear and having pulleys on their ends. The thrust is taken up by ball thrust bearings. Feed of the drill spindles is operated by a handwheel at the right-hand side of the machine, which has a spur gear connection to a rim gear located inside and concentrically with faceplate *H*. The rim gear carries a segment feed cam for each head, that has roller contact with the feed yoke of each drill head. These yokes have a clamp connection to the sleeve on the outer end of the drilling spindles, and this clamp connection provides ready means of adjusting the feeding position of the drill spindles.

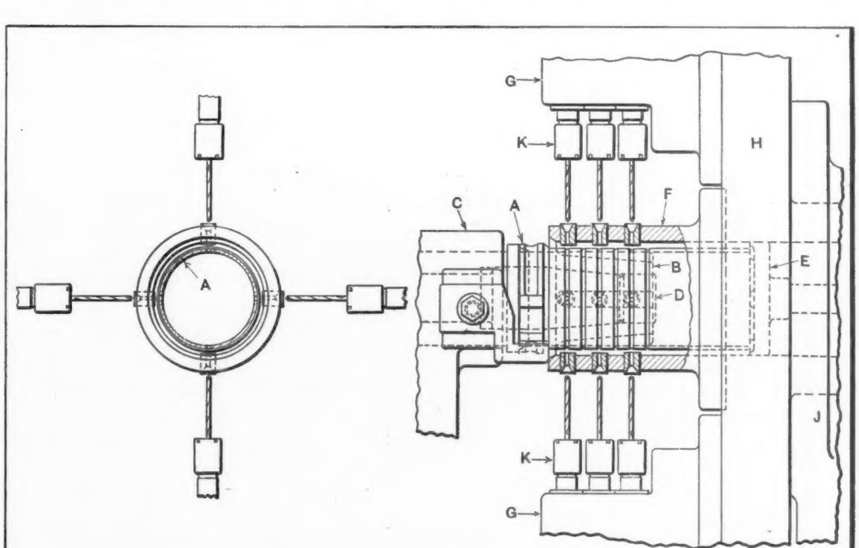


Fig. 3. Section through Drill Jig showing Arrangement of Work-holding Arbor

The drill spindles are driven by pulleys which receive power from an endless belt; the belt, in turn, is driven by two large drivers which are geared to the main driving pulley. The main pulley is driven by belt from a tight and loose pulley drive attached to the bed of the machine. The belt is shifted by the hand-lever located on the bed of the machine. The drilling jig has a compressed air arrangement that blows out chips. The drill speed is 2500 revolutions per minute and the tight and loose pulleys are run at 446 revolutions per minute; floor space occupied is 4 feet by 6 feet, 1¾ inches; height of machine is 5 feet, 9 inches; and net weight, 3500 pounds.

SILVER GANG DRILLS

The Silver Mfg. Co., Salem, Ohio, is now manufacturing gang drills of the type shown in the accompanying illustration with two, three and four spindles. These machines are made in four styles with plain lever feed, lever and wheel feed, power feed and automatic stop, and back-gearing. It will be seen that there is a separate column and table for each spin-

Fig. 1. Silver Three-spindle Gang Drill

dle; the countershaft is driven by a single belt, and an individual belt drive is provided for each drill of the gang. Each machine has one friction tapping attachment, and each spindle may be equipped independently of the others.

The countershaft has the driving pulley placed at the center, while clutches transmit power to the cone pulleys provided for driving independent spindles. This makes it possible to operate all spindles at the same time or to operate any one spindle independently of the others. The principal dimensions of the machine are as follows: height, 68¼ inches; diameter of column, 5½ inches; diameter of round table, 16 inches; size of square table, 16½ by 16½ inches; diameter of spindle, 1⅜ inch; vertical travel of spindle, 10 inches; vertical travel of table, 16 inches; distance from column to center of table, 10¼ inches; distance from spindle to base, 41⅛ inches; distance from spindle to table, 26⅝ inches; distance between spindles, center to center, 18 inches; diameter of crown gear, 5 3/16 inches; diameter of bevel pinion, 3⅜ inches; diameter of large pulley on cone, 9¼ inches;

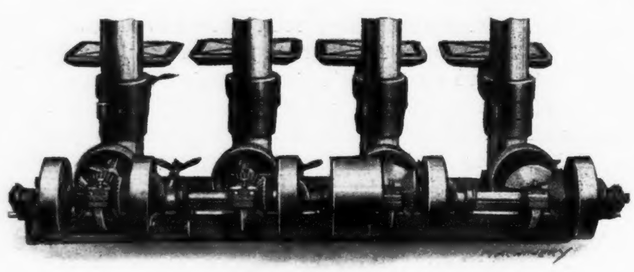


Fig. 2. Countershaft on Silver Four-spindle Gang Drill

diameter of small pulley on cone, 4 inches; width of cone pulley belt, 2 inches; floor space occupied, including countershaft, 41½ by 42½ inches for two-spindle machine; 41½ by 60 inches for three-spindle machine; and 41½ by 78 inches for four-spindle machine.

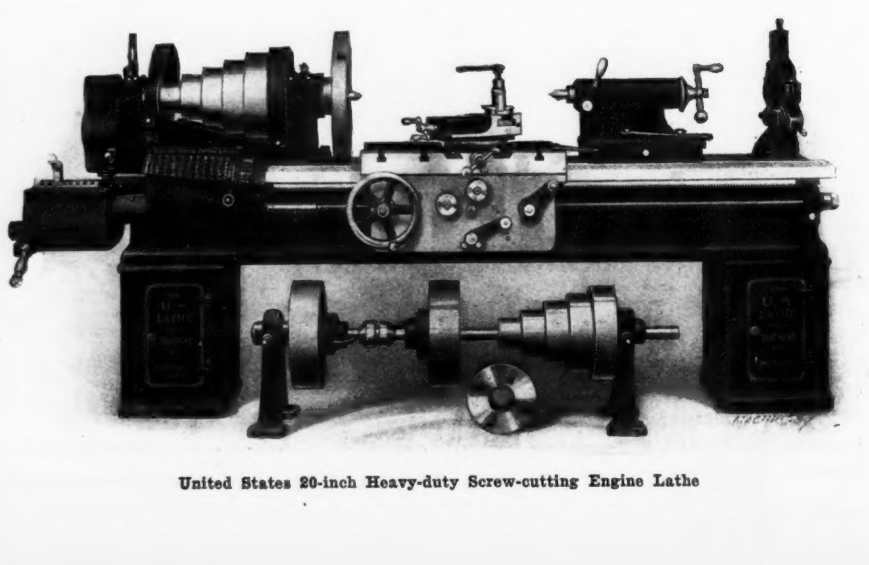
UNITED STATES ENGINE LATHE

The United States Lathe & Machine Co., Cincinnati, Ohio, is now building the 20-inch heavy-duty screw-cutting engine lathe illustrated in connection with the following description. It will be seen that this machine is driven by a five-step cone pulley from which power is transmitted through single back-gears; and a quick-change gear-box provides for cutting from 1 to 32 threads per inch, including 11½ threads per inch. It will be noticed that the quick change in gears locks downward, thereby preventing the lever from working loose. The back-gear lever is of a positive locking type and is easily operated.

The tailstock is provided with an easily accessible lever at the front, and a very short movement of this lever instantly releases or securely locks the spindle against the top, thereby retaining an accurate center position. The legs are of the cabinet type affording a convenient place for the storage of tools, etc. Regular equipment furnished with the machine includes large and small faceplates, a center-rest, complete countershaft equipment and the necessary wrenches for making all adjustments. Extra equipments which may be furnished include a taper turning attachment for turning tapers up to 4⅛ inches per foot, which travels with the lathe carriage and is available from center to center; a center-rest; and an 8-, 10- or 12-inch follow-rest. The United States Lathe & Machine Co. will also build this lathe in a double back-geared type; and it is planned to build larger lathes of the same design.

METALWOOD SHELL BANDING PRESSES

The accompanying illustrations show two machines which constitute recent additions to the line of hydraulic presses built by the Metalwood Mfg. Co., Leib and Wight Sts., Detroit. Mich. The press shown in Fig. 1 is for use in compressing copper bands onto shells from 6 to 12 inches. This is the familiar form of equipment in which six rams operated by hydraulic pressure from a pump or accumulator converge onto the copper band and force the metal to flow into the band seat.



United States 20-inch Heavy-duty Screw-cutting Engine Lathe

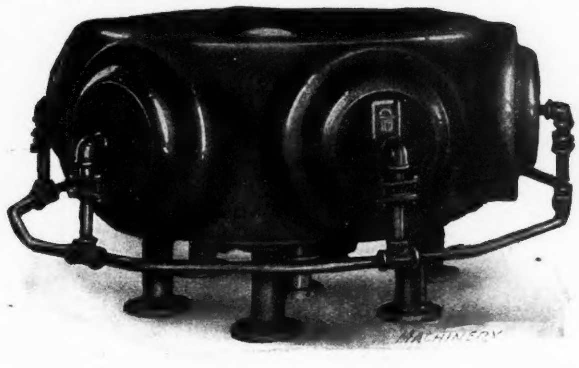


Fig. 1. Metalwood Shell Banding Press for Shells from 6- to 12-inch Sizes

The machine shown in Fig. 2 was developed for banding British Mark IV and V shells. It will be seen that this press is used in connection with a knock-out plug that is placed in the base of the press to protect the shell from distortion or collapse during the banding operation. This press is operated from an accumulator under a pressure of 2500 pounds per square inch. The speed of the ram, pressure, and return movement of the ram are controlled by a Metalwood single-lever quick-operating valve. The press is constructed entirely of steel and has a constant pressure pull back from the accumulator line.

In operation, the shell is placed in the die on the revolving table which is supported on ball bearings. The arbor is

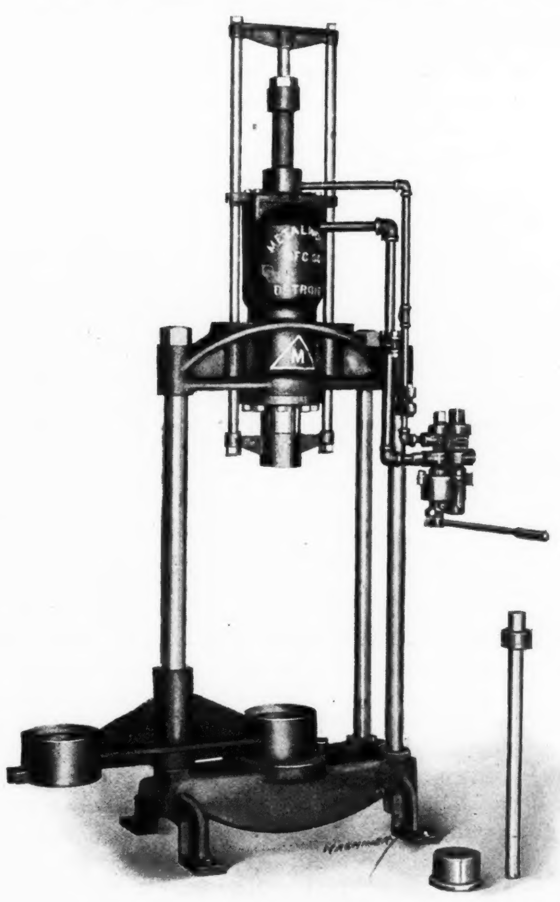


Fig. 2. Metalwood Vertical Shell Banding Press for British Mark IV and V Shells

dropped into the nose of the shell, after which the table is swung around to bring the arbor and shell into position under the ram, where the table is held by a latch which is operated by foot-treadle for release. When the ram descends, the shell is forced down through the die which results in compressing the copper band into its seat in the shell. While the operation of pressing one shell is going on at one end of the table, the other end of the table is unloaded, after which another shell is put in position in the die ready to be swung around to the operating position.

FRASER INTERNAL AND SURFACE GRINDING ATTACHMENTS

In the August number of MACHINERY, a description was published of the universal grinding machine built by the Warren F. Fraser Co., Freeport St., Boston, Mass. Mention was made of the fact that the machine is adapted for performing internal and surface grinding operations, and that the capacities for

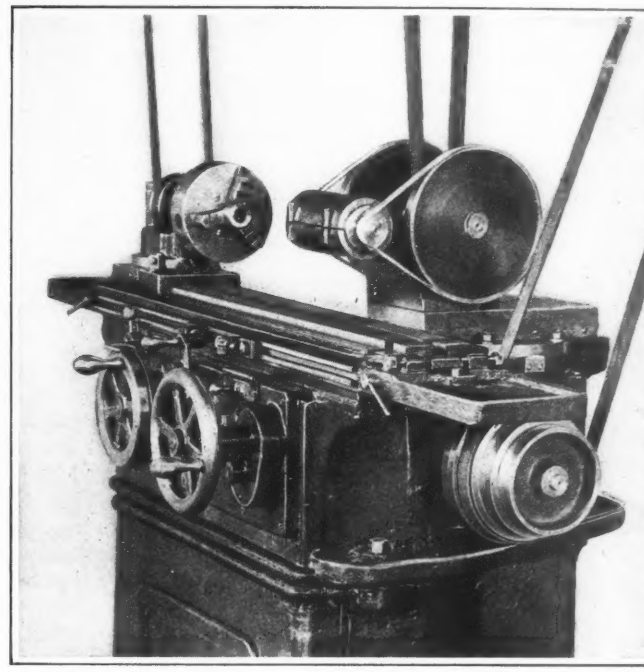


Fig. 1. Fraser Universal Grinding Machine set up for Internal Grinding

work of this kind are for internal grinding in pieces up to 8 inches in diameter, and for surface grinding on work 20 inches in length by 5 inches in width. At the time this article was published, illustrations of the internal and surface grinding attachments were not available, and these equipments are shown in the accompanying illustrations.

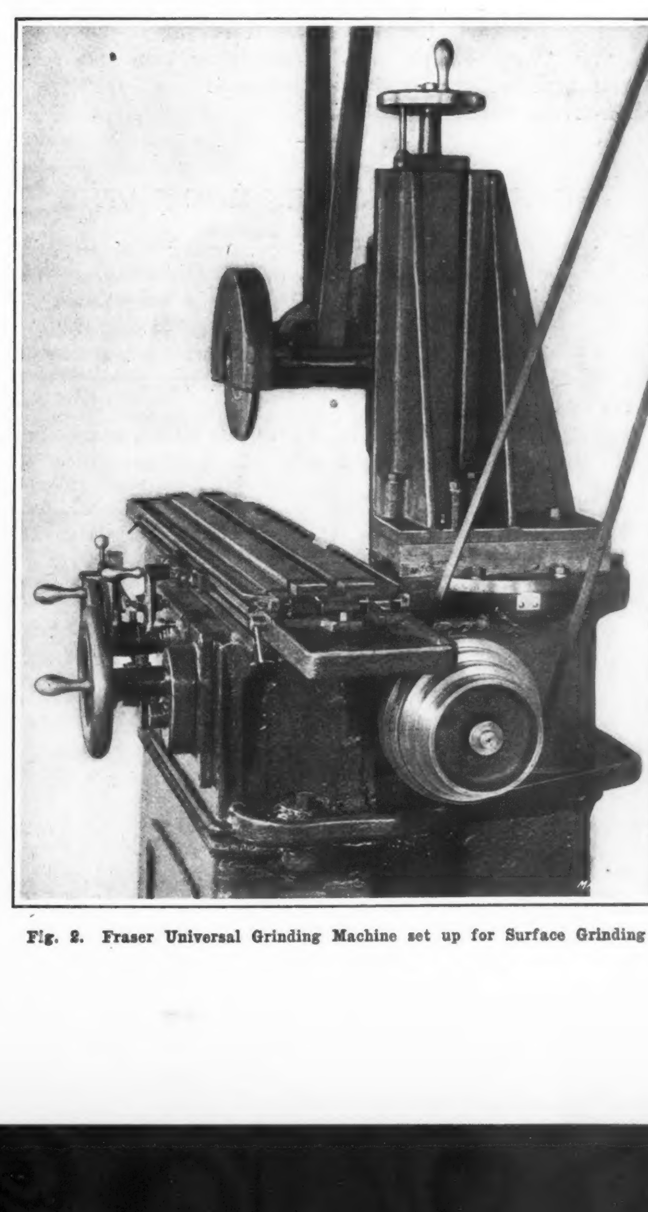
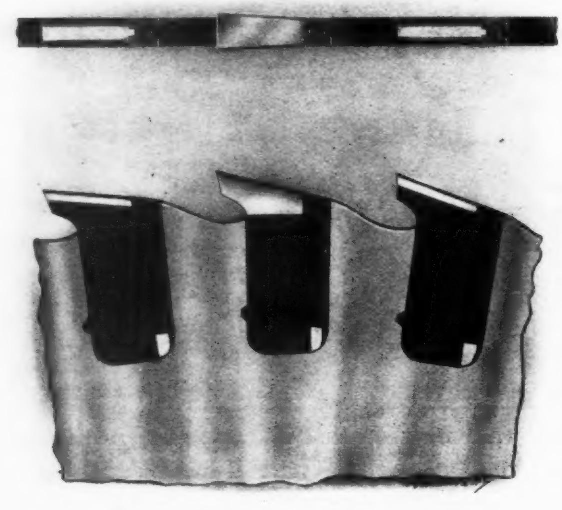


Fig. 2. Fraser Universal Grinding Machine set up for Surface Grinding

SIMONDS INSERTED-TOOTH METAL SAWS

The Simonds Mfg. Co., Fitchburg, Mass., is now manufacturing inserted-tooth metal cutting saws of the type shown in the accompanying illustration. The plate or body of the saw is made of high-carbon steel which is carefully heat-treated and flattened without hammering; the inserted teeth are made of high-speed steel, and the projection at the front holds the bottom of each tooth firmly on the plate so that the tooth cannot work up or down. This makes it unnecessary to drive the wedge in so hard as to disturb the tension or distort the saw plate in any way. Referring to the plan view, it will be seen that alternate teeth are oval and square at the point. The oval teeth are slightly higher than the square teeth, and this allows them to cut a channel in front of the square teeth which



Simonds Inserted-tooth Metal Saw with Alternate Teeth Oval and Square

results in breaking the chips into three pieces and allows them to clear more freely. It also avoids trouble from the material becoming welded to the face of the teeth and at the side of the saw. These saws are made in three sizes, known as Nos. 0, 1 and 2, respectively, and they are made to fit any type of arbor-driven machine.

PUTNAM 42-INCH ENGINE LATHE

In the September, 1915, number of MACHINERY, mention was made of a 42-inch heavy-duty engine lathe, especially adapted for machining large forgings. This machine was built by the Putnam Machine Co., Fitchburg, Mass., and recently this firm has built machines of similar design but with certain modifications to adapt them for turning and boring operations on large gun forgings.

It will be seen that the lathe is equipped with a geared head and direct-connected motor drive. The arrangement of the

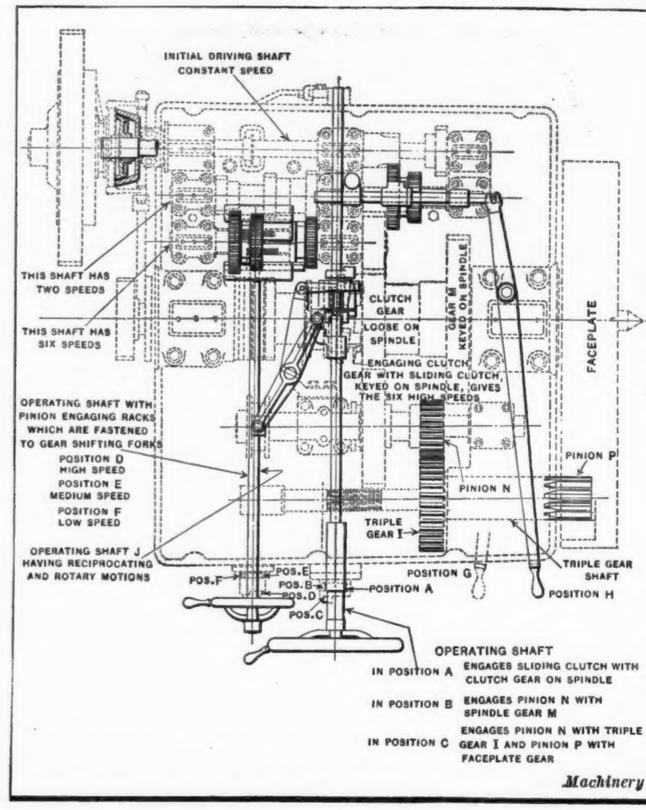


Fig. 2. Arrangement of Gearing in Head of Putnam 42-inch Lathe

gearing in the head is shown in Fig. 2. Eighteen changes of speed are provided by this mechanism, which are in geometrical progression and cover a range of 3.04 to 178.3 revolutions per minute. It will be seen that the sliding gears at

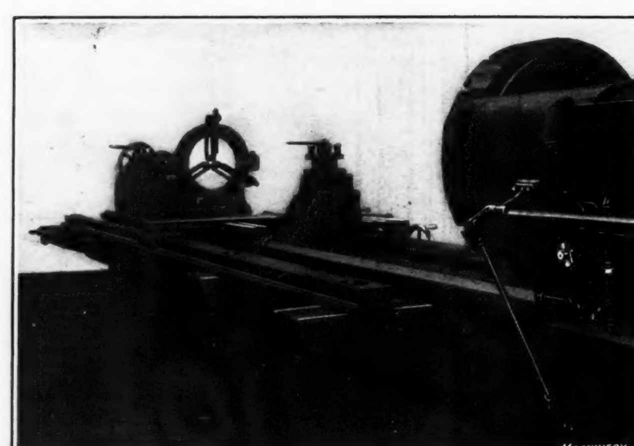


Fig. 3. Taper Attachment which has Range of Entire Distance between Centers

the back of the headstock furnish six changes of speed, and any of these speeds may be transmitted to the spindle by engaging the clutch which provides for securing the first spindle gear, which otherwise runs free on the spindle. Six more changes of speed are provided by allowing the first spindle gear to run free, thus transmitting the drive through backgears to the second spindle gear. The remaining six changes of speed are provided by transmitting the drive through gearing in the position shown in the illustration, connection being made in this case with the gear teeth in the faceplate. A feature of the headstock design is that all shafts and gears are placed horizontally in the headstock casting proper, and they are on the same plane and not in the upper half or cover, so that easy access may be had to all

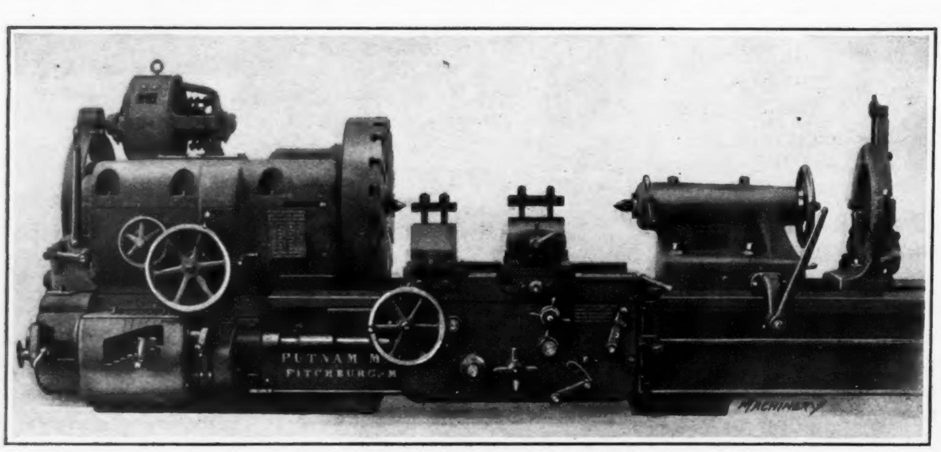


Fig. 1. Putnam 42-inch Engine Lathe for machining Gun Forgings

parts of the headstock. All bearings are capped, making it an easy matter to remove any shaft in case of necessity.

Fig. 3 shows a rear view of the machine and clearly illustrates the arrangement of the taper attachment. No disconnection of any part is necessary in order to engage or disengage the attachment. It can be used for turning outside or boring inside work, where a taper is required, and owing to the fact that it is bolted to the carriage with which it travels, the taper attachment is available for the entire distance between centers. The principal dimensions of this machine are as follows: swing over ways, 43½ inches; swing over compound rest, 32½ inches; swing over taper attachment, 29¾ inches; maximum distance between centers for 19-foot bed, 10 feet, 11 inches; diameter of hole in spindle, 2⅛ inches; length of carriage on bed, 48 inches; range of longitudinal feeds, 0.28 to 0.02 inch; range of cross-feeds, 0.28 to 0.02 inch; travel of tailstock spindle, 19 inches; range of taper attachment, up to 10 degrees, or 4 inches per foot; maximum opening in center-rest, 18⅜ inches; and weight of machine with 19-foot bed, 29,000 pounds.

RADIAL ROLLER BEARINGS

For use on heavy motor vehicles, heavy machinery and journals subject to severe loads, the Ball & Roller Bearing Co., Danbury, Conn., has introduced the radial roller bearings which form the subject of this description. These bearings are suitable for use under a wide range of speeds, and are found particularly useful for application where space is so limited that there is not room for a radial ball bearing sufficiently strong for the load. These bearings are furnished in the two types illustrated herewith, one of which is a so-called full roller type, while the other is provided with a roll separator. In each case, the inner race is channeled to form a groove or track for the rollers, while the outer race is a straight cylinder, so that the rollers are free to take up their correct position in the outer race. The separator or roller cage is made of bronze cast metal, carefully machined on all surfaces and designed to float freely with the rollers. In order to secure satisfactory service from these bearings, it is said to be essential for the tracks or paths of the rollers in the inner and outer races to be perfectly parallel with each other, and as a result accurate machining is absolutely necessary.

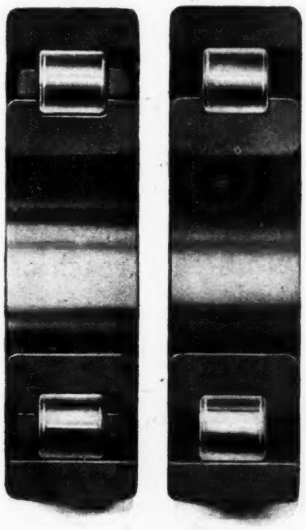


Fig. 1. Radial Roller Bearing with Separator

Fig. 2. Roller Bearing without Separator

It will be obvious from the illustrations that side thrust can under no conditions be imposed upon these bearings, even to locate a shaft endwise. Both the inner and outer races may be made press fits, shoulders being frequently provided to locate them in their respective positions; but care should be taken when this is done to see that the bearing is not unduly tightened. Where end thrust exists, ball thrust bearings or roller thrust bearings must be provided to take the thrust load. Owing to their high carrying capacity, these radial bearings are suitable for use where the conditions of service are very severe; and they can be employed in place of large, plain bearings, which would, of necessity, have to be carefully fitted and scraped. If there is no end thrust other than end location of a shaft, plain thrust collars are often sufficient to meet requirements.

The limits of accuracy to which these bearings are ground, both as regards bore and outside diameter of the rings, is within 0.0003 inch minus or 0.0002 inch plus the specified size. The thickness of the rings is ground to standard dimensions with a limit of 0.005 inch in either direction. So far as lubrication is concerned, radial roller bearings should be treated in precisely the same way as ball bearings and the same lubricants may be used, except in the case of very high speeds, when a mineral oil will be found to give better satisfaction. In this respect, radial roller bearings have the same advantage as ball bearings in that they only require the renewal of lubricant at long intervals. To protect them from dust and moisture is absolutely essential, and a suitable method of guarding against this is to bring the housing down within 0.004 inch of the shaft and provide grooves which form oil pockets, into which the grease finds its way and makes a more or less perfect shield against the admission of moisture or dirt.

NEW MACHINERY AND TOOLS NOTES

Endless Fabric Belt: Victor Endless Belt Co., Camden, N. J. An endless fabric belt which is oil-proof and waterproof, and especially adapted for high-speed drives on short center distances. It is claimed that these belts are stronger than leather belts of the same width and thickness.

Universal Machine Tool: J. L. Kunz Machinery Co., Milwaukee, Wis. A machine designed for use in small shops where the amount of one kind of work to be done is not sufficient to warrant the purchase of a single-purpose machine. The machine may be adapted for the performance of milling, keyseating, gear-cutting and kindred operations.

Motor-driven Grinder: Ransom Mfg. Co., Oshkosh, Wis. A machine known as the No. 35 grinder which is equipped with two wheels 18 by 3 inches. These wheels are protected by guards constructed of tank steel, and are fitted with glass eye shields. The spindle of the machine is started or stopped by the operation of a foot-treadle at the front of the grinder.

Lubricant Pump: C. F. Roper & Co., Hopedale, Mass. This company is now building one-way and reversing lubricant pumps in three sizes which have capacities of 8, 16 and 46 quarts per minute when running at 500 revolutions. The design is very similar to that of pumps of this company's manufacture which were referred to in the May number of MACHINERY.

Tool-holder: H. P. Parrock, General Manager, Lumen Bearing Co., Buffalo, N. Y. A tool-holder in which the bit is machined to a size slightly larger than a slot cut in the shank of the tool; to secure the bit in place, the shank is heated so that the groove expands sufficiently to allow the bit to be dropped into place; and when the shank cools, the contraction of the metal causes it to secure a firm grip on the cutter.

High-speed Steel-tipped Drill: Campbell Mfg. Co., 3715 Wentworth Ave., Chicago, Ill. This company is now manufacturing a line of drills with inserted high-speed steel tips. The tips are easily inserted or removed, and seven different sizes of tips are furnished with each size of shank. Either straight or fluted shanks may be used, according to the requirements of the work. The tips are about 2 inches in length.

Shear and Rod Cutter: In the July number of MACHINERY a description was published of the No. 2 shear and rod cutter built by W. M. & C. F. Tucker, Hartford, Conn. This machine was of the floor type, but to meet the requirements of shops where a considerable amount of light work is to be done, the same machine has been built in a bench type adapted for handling smaller work. In other respects, the design of both machines is the same.

Geared-head Lathe: Phoenix Mfg. Co., Eau Claire, Wis. A lathe in which the headstock is cast integral with the bed, and in which the spindle is driven through duplex worms and worm-wheels of widely varying range with sliding gears to obtain the required range of speed. The lathe swings 21½ inches over the ways and 14 inches over the carriage; capacity between centers for a 10-foot bed is 5 feet, 1 inch; and weight of machine is 5750 pounds.

Engine Lathe: Axelson Machine Co., Los Angeles, Cal. A 16-inch engine lathe driven by a four-step cone pulley and single back-gears. The swing over the bed is 17½ inches, and over the carriage, 10½ inches; the back-gear ratio is 9.6 to 1; the available speeds range from 6.67 to 350 revolutions per minute; and there are thirty-two changes of feed provided by a quick-change gear-box. With a 6-foot bed, the weight of the machine is 2400 pounds.

Belt Tension Machine: Tabor Mfg. Co., Philadelphia, Pa. A machine for use in applying tension to new belts or belts which have been repaired, preparatory to placing them on the pulleys. The machine consists of a pulley or drum over which the belt is placed and secured at each end by clamps. The bed is graduated to facilitate setting the clamps for any length of belt that is required to be tensioned, and means are furnished for applying tension to the belt.

Dynamic Balancing Machine: Dynamic Balancing Machine Co., Philadelphia, Pa. In the September, 1915, number of MACHINERY a description was published of the dynamic bal-

ancing machine which had just been placed on the market by the Dynamic Balancing Machine Co. at that time. Recently a small machine has been introduced for use in balancing small motor armatures, couplings, etc. The principle of operation is the same as that of the larger machine.

Power Press Clutch: Campbell Mfg. Co., 3715 Wentworth Ave., Chicago, Ill. In the operation of power presses, the average speed of the flywheel is from 80 to 200 revolutions per minute, but the application of this new clutch makes it possible to employ speeds ranging from 80 to 1000 revolutions per minute. When the clutch is used on other types of machinery, it will operate satisfactorily and positively at speeds ranging from 500 to 5000 revolutions per minute.

Gage Standards: Wismach & Co., 1513 Richard St., Milwaukee, Wis. These are block gages with parallel lapped opposite sides; they vary in thickness by specific increments, given in fractions of inches or millimeters, and two or more blocks can be wrung together to obtain what is practically a solid gage of any required size. Holders are provided for the blocks when they are used for external measuring or for measuring holes with two half-round members furnished for that purpose.

Portable Electric Tools: Standard Electric Tool Co., Cincinnati, Ohio. This company has added to its line a combination drilling and polishing machine; when used for polishing, the wheel arbor is interchanged with the drill chuck. The tools are driven by a one-half horsepower motor adapted for use on 220 volts, 50 cycle, three-phase circuit, which runs at 950 revolutions per minute. The feed reduction is obtained through a gear-box at the lower end of the motor case, which provides a reduction of 4 to 1.

Car Wheel Lathe: Niles Tool Works Co., Hamilton, Ohio. An unusually heavy car wheel lathe which is provided with central driving gears and pinions of the herringbone type. The wheels are rolled onto the lathe on a short hinged track which makes connection with the shop track, and an elevating device is provided for aligning the work with the tailstocks. For wheels on axles with outside journals, collapsible bushings fitting over the journals and tapered to fit the tailstock spindle are provided for use on the machine.

Plain Grinder: Ram Engineering Co., Richmond, Ind. A 10- by 31-inch plain horizontal grinding machine which has capacity for handling a large range of work. The cross-feed is operated by a screw with a graduated collar, and a special form of nut is provided which takes up all backlash. The table is also operated by a screw with a graduated collar and is furnished with adjustable stops. The machine may be provided with additional accessories, such as universal headstock, table for taper grinding, internal grinding attachment, faceplate, steadyrest, etc.

Riveting Machine: Vulcan Engineering Sales Co., 2059 Elston Ave., Chicago, Ill. A riveting machine built by the Hanna Engineering Works, for which the Vulcan Engineering Sales Co. has the sales agency. This is a pneumatic riveting machine, and in general respects the design is similar to that of the pneumatic riveter of this company's manufacture described in MACHINERY for March. The former machine was intended for riveting latticed columns, while the present machine has been developed to meet the requirements of riveting operations on automobile and similar work.

Engine Lathe: Oliver Machinery Co., Coldbrook and Clancy Sts., Grand Rapids, Mich. An 18-inch lathe designed for taking heavy cuts at high speed. A feature is that all parts of the lathe are jig machined, so that replacement parts may be substituted without the necessity of doing any fitting in the shop. The lathe is driven by a three-step cone pulley and double back-gears; and a quick-change gear-box is provided in which thirty-two changes of feed may be obtained by operating two levers. A taper attachment is provided which has a capacity for turning tapers up to 4 inches per foot.

Motor-driven Grinder: Standard Machine & Electric Co., Indianapolis, Ind. This machine may be equipped with a motor for connection with either alternating- or direct-current circuits. The spindle carries two grinding wheels which may be 1½ by 12 inches or 2 by 12 inches in size. The wheel spindle runs in ball bearings, and the wheels are enclosed to provide for the safety of the operator. An exhaust system is an integral part of the machine, and is driven by the same motor which drives the grinding spindle. The driving motor is started or stopped by means of a foot-treadle at the front of the machine.

Automatic Screw Machine: Fitchburg Automatic Machine Works, Fitchburg, Mass. A four-spindle machine known as the "Radical" automatic, which combines a number of interesting features. In working out the design, particular attention has been given to the development of a rigid construction and a design which is as simple as possible. The claim is made that this machine contains only six hundred parts, while other machines of similar design have approximately twice this number of parts. At the present time the "Radical" automatic is built in two sizes which have capacities for work up to 1 and 1¼ inch in diameter; but it is planned to build three other sizes having capacities for work up to 9/16, 1 1/2 and 2 inches in diameter.

FOREIGN TRUST LAWS

LAWS REGULATING COMBINATIONS, MONOPOLIES, AND PATENTS IN GREAT BRITAIN, CANADA, AUSTRALIA NEW ZEALAND AND GERMANY

During the past two years the factors governing and influencing the development of foreign trade have been carefully studied by both the American manufacturer and the commercial bodies of this nation. One result of this study has been the discovery that the trade of the European countries has been promoted largely through the cooperation of the producers, manufacturers, exporters and bankers, and that these have had the cooperation of the state. The present indications are that at the close of the war nations will cooperate to meet the competition of groups of nations. As the United States stands alone among the commercial nations of the world, its trade can be built up and held only by the cooperation of its exporters and manufacturers. For this reason the Webb bill recently introduced in Congress authorizes the cooperation of American exporters. In order that the American exporter may know the conditions against which he must work, the Department of Commerce has issued a bulletin entitled "Trust Laws and Unfair Competition," from which the following abstracts have been made:

Chief Justice White, in the Standard Oil case, said that the public outcry against monopolies was due to the power that a monopoly gave to one to fix the price and thereby injure the public, to limit the production, and to allow a deterioration of the article. He then said that so far as the necessities of life were concerned, laws were passed prohibiting individuals to deal under circumstances and conditions that created a presumption that the dealings were not simply the honest exertion of one's right to contract for his own benefit unaccompanied by a wrongful motive to injure others, but were the consequence of a contract or a course of dealing of such a character as to give rise to the presumption of an intent to injure others through the means, for instance, of a monopolistic increase in prices.

The laws that regulate the formation of combinations, etc., however, vary widely in various countries. The monopolies granted by the English Crown became so numerous and obnoxious that in 1601 many of them were abolished by Parliament, and in 1640 the most of them were declared void. At present the only law in England affecting combinations to control the market is the common law. According to this, any member of the community is entitled to carry on any trade or business he chooses, and in such manner as he thinks most desirable in his own interests; and inasmuch as every right connotes an obligation, no one can lawfully interfere with another in the free exercise of his trade or business unless there exists some just cause or excuse for such interference.

In common law no contract was ever an offence merely because it was in restraint of trade. To make such a contract or combination unlawful, it must amount to a criminal conspiracy, as the right of an individual to carry on his business in the manner that he deems best in his own interests involves the right to combine with others in a common course of action.

The policy of the English law is to encourage competition, but it apparently places no serious obstacles to combination. In the interpretation of contracts of sale of property and business, the English courts, in recent years, have given them a more liberal construction than have the courts of the United States in those cases in which the common law has been applied, and have been willing to aid the enforcement of contracts of combinations in restraint of trade or to control the market that in the United States would have been declared against the public policy.

Canadian Trust and Patent Laws

In Canada action may be brought against a trust under statutes in the criminal code, or the customs, patent and inland revenue laws, or the Combines Investigation Act. According to the criminal code, it is unlawful:

> To unduly limit the facilities for transporting, producing, manufacturing, supplying, storing, or dealing in any article or commodity; to restrain or injure trade or commerce in relation to any such article or commodity; to unduly prevent, limit, or lessen the manufacture or production of any such article or commodity, or to prevent or lessen competition in the same.

The patent law provides that if a patentee does not meet the reasonable requirements of the public in regard to patented article, compulsory licenses may be issued for its manufacture. If a patentee should refuse to comply with an order to grant a license, the patent may be declared void. The customs law provides that if the governor in council should find that there is a combination of manufacturers or dealers of any article that is injurious to the consumers, he may remove or reduce the duty on the article, in order to give the consumers the benefit of reasonable competition.

According to the Combines Investigation Act, if six citizens believe that a combination is in restraint of trade, they may bring action and cause a board to be appointed. Should this board find that the alleged condition exists, it may cause the removal or reduction of customs duties, the revocation of letters patent, and criminal prosecution. The only proceedings brought under this act were against the United Shoe Machinery Co. of Canada, when it was found that the leases of this company unduly restricted competition in the manufacture, sale, etc., of shoe machinery.

Australian and New Zealand Laws

The Australian Industries Preservation Act aims especially at the repression of monopolies and the prevention of dumping. It forbids contracts and combinations that will affect adversely the commerce of Australia and other countries or among the different states. But any person may defend his act by showing that the restraint was not to the detriment of the public or that the restraint is not unreasonable. Any person who monopolizes or attempts or conspires to monopolize commerce with other countries or among the states is guilty of an indictable offense. Instead of proceeding by indictment, however, the attorney-general may bring a civil action for the recovery of the fines imposed, without jury trial. The refusal to deal with a person, except under disadvantageous conditions, because such person deals with some other person or with persons not belonging to a commercial trust, is an offense in certain cases. A person may, however, declare the fact and purposes of the contract or combination to the attorney-general, and await his decision. Any proceedings brought against him before he receives the attorney-general's decision will not hold.

The patent laws provide for the granting of compulsory licenses and the revocation of letters of patent. Among other things, the patentee is held to be at fault if he has failed to grant licenses so that the demand for the patented article is not fully met, or the establishment of any new trade or industry in Australia is unfairly prejudiced. Patentees are forbidden to insert clauses in their leases, etc., restricting the other parties to the use of the article patented.

The Interstate Commission has very broad powers over all things connected with trade. In its first annual report it stated that a combination existed among the printers of Victoria, by which those in the association were given preferential treatment in the purchase of supplies. The commission found that while the combination may not have been illegal, it was contrary to the intention of Parliament, when it passed the Industries Preservation Act, because it caused the non-combination printers to purchase their supplies abroad. The chief commissioner suggested that the protective duties be remitted in such cases.

New Zealand has no general laws forbidding trusts. The two more important ones are restricted to agricultural implements, coal, meat, flour, etc. They prohibit the giving of rebates and make any person who conspires to monopolize the demand or supply of goods guilty of an offense, if such monopoly is contrary to the public interest. These laws declare that a commercial trust is any association having as one of its objects controlling or influencing the supply or demand or price of any goods in New Zealand or elsewhere, or creating or maintaining a monopoly in the supply or demand of goods. In one case the court said: "If the monopoly or control sought to be obtained can only be obtained by breaches of the law it is of such a nature as to be contrary to the public interest, although if it could have been obtained without breaches of the law it might not have been contrary to the public interest."

According to the New Zealand law, the governor may cause licenses to be granted if he is convinced that the patent is not being worked in New Zealand, that the reasonable requirements of the people cannot be supplied, or that any person is prevented from working or using to the best advantage an invention of which he is possessed.

Germany's Trust Laws

Germany's civil code, like England's common law, provides that "the pursuit of an industry is permitted to everyone, in so far as exceptions or limitations are not imposed or permitted in this law." This provision, though, permits combinations to exist. The Imperial Court has said:

> If in any branch of industry the prices of products sink too low and if the thriving operation of the industry is thereby made impossible or endangered, the crisis which occurs is destructive not only for individuals, but for the social economy in general, and it lies, therefore, in the interest of the whole community that unduly low prices shall not permanently exist. . . . Agreements of the kind under consideration can therefore be questioned from the standpoint of the protection of the general interest through the freedom of industry.

The Imperial Court has held that a book dealers' combination that fixed rebates and discounts was lawful, and the highest court of Bavaria has held that a combination of tile manufacturers that fixed prices and limited production was not against good morals, but rather both a valid and a prudent business arrangement. The civil code, however, says:

> Whoever in business affairs, for the purpose of competition, commits acts which are repugnant to good morals may be subject to an action to desist therefrom and to pay damages.

In the case of potash, spirits, beer, matches, and a few other industries, the laws have been so framed that combinations are favored. The general purpose of the potash laws is to regulate production and prices so that there will not be an excessive competition between producers nor very high prices for the consumers. This condition was created to conserve the supply of the material and prevent its exhaustion by wasteful mining or selling methods. Low prices in the domestic market are established by a direct fixing of price, and export sales are generally made at higher prices, though the export prices are not uniform. These laws, however, have failed in preventing unfair competition or the multiplication of mines.

Both Germany and the individual states have laws forbidding the formation of combinations for bidding on the public contracts. Combinations that restrain trade can also be punished by the provisions of the penal code. For instance, the Imperial Court condemned a combination of powder manufacturers that refused to supply dealers who would not patronize it exclusively, and who also threatened to discontinue the supply of a customer who had purchased goods from a competitor. This code also imposes penalties on those who exploit the necessity, thoughtlessness, or inexperience of another in order to obtain for themselves or a third party a pecuniary advantage that is greatly disproportionate to the service rendered.

Because of the conditions found to exist between a tobacco firm and a British American company, it is said that the following section was to be added to the penal code just before the outbreak of the war:

> Participation in a society whose existence, constitution, or purpose shall be kept secret from the government or in which is promised obedience to an unknown superior or unconditional obedience to a known superior makes the members punishable with imprisonment up to six months and the promoters and leaders of the society with imprisonment from one month to one year. D. E. J.

* * *

Don't run the diamond across the wheel rapidly if you wish a good smooth finish, as such a procedure will cause the wheel to be imperfectly trued, and mottle marks are likely to appear on the work. On the other hand, don't run the diamond too slowly across the wheel if you wish the surface broken up so that it will cut freely and quickly.—*Grits and Grinds.*

PERSONALS

C. K. Cairns, formerly with the American Tool Works Co., Cincinnati, Ohio, has resigned, to become sales manager of the Cincinnati Pulley Machinery Co. of Cincinnati, manufacturer of the "Avey" drilling machines.

Henry H. Powell has been appointed manager of the buying department of William P. Bonbright & Co., Inc., 14 Wall St., New York City, taking effect September 1. Mr. Powell has been associated with N. W. Halsey & Co. in a similar capacity for ten years.

Merritt H. Barnes, formerly of the Boston office of the Prentiss Tool & Supply Co., now Henry Prentiss & Co., Inc., New York City, machine tool dealer, has been transferred to the Scranton office of the company. Mr. Barnes will cover the territory formerly handled by S. N. McFadden, resigned.

Frank G. Bolles, formerly manager of the publication *International Trade*, of Chicago, has been made vice-president of R. Martens & Co., Inc., New York City, and Petrograd, Russia, and will be in immediate charge of the subsidiary Russia Trade Corporation of America, recently formed. This concern will handle all kinds of general merchandise.

OBITUARIES

John H. Allen, president of the John F. Allen Co., New York City, maker of the original Allen riveting machine, died at his summer home at Kattskill Bay, Lake George, N. Y., aged fifty-seven years. Mr. Allen succeeded his father, who founded the business some forty-five years ago.

R. J. Collins, who for the past twelve years was connected with the Cataract Refining & Mfg. Co., Buffalo, N. Y., died at his home in Buffalo July 20. Mr. Collins was sales manager of the cutting compound department for the past six years, and had many friends among the machine tool builders throughout the country. He was well liked because of his attractive personality and genial qualities.

Charles Kirchhoff, for many years editor-in-chief of the *Iron Age*, died July 22 at his summer home near Asbury Park, N. J., aged sixty-three years. Mr. Kirchhoff enjoyed the friendship of many prominent men in mining and metal trade circles. He was elected president of the American Institute of Mining Engineers in 1898. He took a great interest in the industrial safety movement, and was a charter member of the American Museum of Safety and one of its vice-presidents.

COMING EVENTS

September 5-8.—Annual convention of the Traveling Engineers' Association at Chicago, Ill. W. O. Thompson, secretary, New York Central Car Shops, E. Buffalo, N. Y.

September 11-16.—Annual convention of the American Foundrymen's Association and the American Institute of Metals, Cleveland, Ohio, in the Cleveland Coliseum. A. O. Backert, secretary-treasurer, American Foundrymen's Association, Cleveland, Ohio.

September 11-16.—Exhibition of machines, equipments and supplies for the foundry and allied industries in conjunction with the annual conventions of the American Foundrymen's Association and American Institute of Metals, at Cleveland, Ohio, in the Coliseum. C. E. Hoyt, manager, 1949 W. Madison St., Chicago, Ill.

September 25-30.—Second National Exposition of Chemical Industries, Grand Central Palace, New York City.

September 27-30.—Annual convention of the American Electrochemical Society in New York City. One of the sessions will be devoted to made-in-America products of the electric furnace and electric cell, including copper, aluminum, abrasives, bleach, etc.

September 28.—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

September 28-30.—Meeting of the American Electrochemical Society at Grand Central Palace, New York City. Secretary, J. Malcomb Muir, 239 W. 39th St., New York City.

October 11-21.—New York Electrical Exposition in the Grand Central Palace, New York City. Arthur Miller, director, Irving Place and 15th St., New York City.

October 24-25.—Annual convention of National Machine Tool Builders' Association, Hotel Astor, New York City, headquarters. Charles E. Hildreth, general manager, Worcester, Mass.

SOCIETIES, SCHOOLS AND COLLEGES

Columbia University, New York City. Bulletin announcing classes in extension teaching.

University of Utah, Salt Lake City. Bulletin of the University of Utah, with lists of students and calendar for 1916-1917.

Carnegie Institute of Technology, Pittsburg, Pa. General catalogue for 1915-1916. Of special interest in this field is the School of Applied Industries, which offers three-year courses in building construction, machine construction, general equipment and installation and printing; and one-year courses in machine shop work, patternmaking, foundry, forging, plumbing, electric wiring, sheet metal working, bricklaying and masonry, mechanical drafting, carpentry and printing. Four-year and two-year evening courses in the same trades are also given.

New York University, New York City. Announcement of the courses of study in the School of Commerce, Accounts and Finance of the New York University. The bulletin contains an article on foreign trade, entitled "American Commerce on the Offensive—Men Needed." The School of Commerce, Accounts and Finance has organized a department of instruction which aims to give students the training necessary for success in foreign trade. Those interested may address inquiries to Major B. Foster, secretary of the New York University School of Commerce, Accounts and Finance, Washington Square E., New York City.

NEW BOOKS AND PAMPHLETS

Standards for Electric Service. Circular No. 56 of the Bureau of Standards. 262 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C.

Correction of Echoes and Reverberations in the Auditorium, University of Illinois. By F. R. Watson and James M. White. 20 pages, 6 by 9 inches. Published by the University of Illinois, Engineering Experiment Station, Urbana, Ill., as Bulletin 87.

Electrical Tables and Engineering Data. By Henry C. Horstmann and Victor H. Tousley. 331 pages, 4¼ by 6½ inches. Illustrated. Published by Frederick J. Drake & Co., Chicago, Ill.

This collection of electrical data is arranged in alphabetical order, and its scope is limited to practical information likely to be needed by the working electrician. The alphabetical arrangement is supplemented by an index to tables, of which there are 132.

The Slide Rule. By Charles N. Pickworth. 124 pages, 5 by 7 inches. 39 illustrations. Published by the D. Van Nostrand Co., New York City. Price, $1.

This is the fourteenth edition of Pickworth's well-known practical manual for the use of the slide rule. This edition has been revised where necessary, and the contents have been further extended to include a section dealing with the solution of algebraic equations by the slide rule. This is probably one of the most complete and thorough treatises on the manifold applications of the slide rule available.

Fundamentals of a Cost System for Manufacturers. 31 pages, 6 by 9 inches. Published by the Federal Trade Commission, Washington, D. C.

The Federal Trade Commission has found that a great number of manufacturers, particularly the smaller ones, have no adequate system for determining their costs, and therefore price their goods arbitrarily. It is evident that there must be improvement in this direction before competition can be placed upon a sound economic basis. With the object of aiding in the improvement of business generally, the commission has endeavored in this pamphlet to show briefly the importance of accurate manufacturing costs and the fundamental principles underlying them.

Industrial Arithmetic. By Nelson L. Roray. 154 pages, 5 by 7½ inches. 85 illustrations. Published by Blakiston's Son & Co., Philadelphia, Pa. Price, 75 cents.

The manuscript of this book has been used for about thirty different classes under several teachers in the Industrial Department of the Dickinson High School, Jersey City, N. J., during the past five years, and the success obtained in its use has prompted the author to publish it in book form. The book should be especially suitable for trade schools and similar institutions, where a teacher is present to guide the work. For home study the instruction matter is probably somewhat too abbreviated, and needs the supplementary instruction of a teacher. For school work, however, the book is unusually complete, and contains a great number of exercises which will force the student to memorize the rules and principles by constant repetition.

Instruction Book on Oxy-acetylene Welding and Cutting. By H. Sidney Smith and A. F. Brennan. 45 pages, 6 by 9 inches. Illustrated. Published by the Prest-O-Lite Co., Inc., Indianapolis, Ind. Price, 50 cents.

This pamphlet is the fourth edition of the instruction book published by the company to help users of "Prest-O-Lite" oxy-acetylene welding and cutting apparatus get best results. It treats of the nature of oxygen and acetylene gases, and of the necessary qualifications of the operator. The construction of the torch is described and the management of the acetylene regulator. Illustrations show the correct welding flame and how the joint should be prepared for welding. Preheating, reheating and annealing are discussed. The book contains in a small compass a large amount of valuable, instructive matter for those using oxy-acetylene welding and cutting apparatus.

Electric Wiring Diagrams and Switchboards. By Newton Harrison. 330 pages, 4½ by 6¼ inches. 120 illustrations. Published by Norman W. Henley Publishing Co., New York City. Price, $1.50.

This is the second edition of a work first published in 1906, which has just been revised; data on transformers and measuring instruments have been added. Practical every-day problems in wiring are presented, and only arithmetic is employed in the computations. A simple explanation is given of Ohm's law with reference to the wiring for direct and alternating currents. The simple circuit is developed with positions of mains, feeders and branches, and their treatment as a part of a wiring plan and their employment in house wiring are clearly illustrated. The book is bound in flexible covers and is well suited to the needs of electricians.

The Use of the Slide Rule. By Allan R. Cullimore. 36 pages, 6 by 9 inches. Illustrated. Published by Keuffel & Esser Co., Hoboken, N. J. Price, 50 cents.

The author of this manual is dean of the College of Industrial Science of Toledo University, and undertook its preparation after recognizing the need of a book to meet the requirements of students taking engineering and industrial courses. The text is based upon sets of notes which were developed for use in classes consisting of engineering students and men possessing more or less practical experience. This book is not in any sense a complete treatise, its aim being to assist the slide-rule user to develop his own ideas rather than to give empirical rules for the use of this instrument. Such rules as have been given are for the purpose of training the students in the development of processes, and the author does not recommend that they be committed to memory.

Five-figure Mathematical Tables. By E. Chappell. 320 pages, 6 by 9 inches. Published by D. Van Nostrand Co., New York City. Price, $2.

This is an entirely new collection of logarithm and similar tables, introducing, in addition to the ordinary logarithm tables, tables of what the author terms "cologs," "illogs" (anti-logarithms), "lologs" (logarithms of logarithms), and "illologs" (anti-lologs). In addition, of course, there are the usual tables of natural trigonometrical functions and their logarithms. In the preface the author calls attention to the fact that the sciences of electricity and thermo-dynamics present fundamental differences with regard to the mathematical expressions appearing in them, as compared with those in the older sciences of mathematics and mechanics, one fundamental difference being that in the newer sciences numbers are frequently raised to fractional powers. Consequently, the logarithm tables of the past, which are especially useful when numbers are raised only to simple powers, cannot be said to reduce the calculations of these new sciences to the simplest possible forms. It is for processes of involution and evolution involving fractional indices that the tables of so-called "lologs" and "illologs" have been calculated. The "lolog," or logarithm of a logarithm, enables the value of an expression such as $1.765^{1.29}$ to be found by simply finding the logarithm of 1.29, adding to it the "lolog" of 1.765, and finding the number corresponding to the "lolog" thus obtained, or, still simpler, finding the "illolog" of the sum. The book gives explicit directions for the use of these various tables, which probably will be found useful to many who have a great deal of engineering calculation to do, involving the raising of numbers to fractional powers. A suggestion that might be made is that a book of this kind, which is frequently referred to and which contains not less than six different classes of tables, should be provided with some kind of thumb index or other means for rapidly finding the class of tables which the user wants at the moment.

NEW CATALOGUES AND CIRCULARS

Richard W. Jefferis Co., Camden, N. J. Folder illustrating and describing Jefferis pressed steel lockers, wardrobes, bins and shelving for modern factory equipment.

Keuffel & Esser Co., 127 Fulton St., New York City. Price list revised to July 1, 1916, superseding the prices listed in the thirty-fifth edition of the Keuffel & Esser general catalogue.

International Machine Tool Co., Indianapolis, Ind. Circular of the "Libby" heavy-duty turret lathe in railroad shops, showing typical locomotive work which the "Libby" lathe handles efficiently.

Electric Controller & Mfg. Co., Cleveland, Ohio. Revised price sheet for E. C. & M. automatic motor starters with angle iron mounting and separate resistors, for non-reversing direct-current motors.

Link-Belt Co., Chicago, Ill. Book 275, containing revised list prices of link-belt, sprocket wheels, traction wheels, gears and malleable iron elevator buckets. These prices supersede those given in catalogue 110.

United States Lathe & Machine Co., Cincinnati, Ohio. Leaflet descriptive of the United States 20-inch heavy-duty screw cutting engine lathe with quick-change gear device, five-step cone and single back-gears.

Bunting Brass & Bronze Co., 748 Spencer St., Toledo, Ohio. 1916 catalogue, covering brass and bronze bearing bushings, cored bars for repair work, etc., giving a complete list of dimensions and prices. The book is attractively bound in flexible cloth.

Cadwell-Vernon Co., Inc., 15 Foote Ave., Jamestown, N. Y. Catalogue of rolling machines for forming sheet metal beading, tubing, etc.; made in four sizes for handling stock from 0.005 up to 0.065 inch thick, 6 inches wide. Larger machines are built to order.

Precision Instrument Co., E. Fort and Beaubien Sts., Detroit, Mich. Leaflet advertising the product of this company, which includes CO_2 recorders, SO_2 recorders, recording gages, indicating gages, draft gages, coal calorimeters, gas calorimeters, boiler testers, water meters, etc.

Ingersoll-Rand Co., 11 Broadway, New York City. Form 3033 describing "Imperial" type "XPV" duplex steam-driven air compressors; form 4122, illustrating and describing the "Leyner" drill sharpener; and form 9024, treating of steam condensing plants of the Beyer barometric type.

Vernon Machine Co., Worcester, Mass. Circular of an eleven-inch, four-step cone pulley engine lathe. The dimensions of the headstock and spindle and the general construction are such that the lathe is suited to a wide range of manufacturing work within its capacity. Weight with five-foot bed, 775 pounds.

Phoenix Mfg. Co., Eau Claire, Wis. Catalogue of Conradson engine lathes, covering geared-head engine lathes, geared-head projectile lathes, and geared-head special lathes, giving illustrations of each type, together with brief specifications. Sectional drawings showing the construction of the geared head are included.

Spray Engineering Co., 93 Federal St., Boston, Mass. Bulletins treating of the "Spraco" system for cooling condensing water, the Vaughan flow meter, and cooling water for ice plants. These bulletins describe in detail the various devices dealt with, and are of especial interest to power plant owners and operators.

Ball & Roller Bearing Co., Danbury, Conn. Catalogue 8 on ball thrust bearings, roller thrust bearings, journal roller bearings, annular roller bearings, anti-friction bearings and cylindrical rollers, giving dimensions and prices. Tables of allowable loads on chrome steel balls and conversion tables giving millimeter equivalents of fractional inches and decimal equivalents of fractional inches are included.

New Departure Mfg. Co., Bristol, Conn. Sheets 71 FE to 74 FE for loose-leaf binder, illustrating and describing rotary screw water lifting mechanism, isolated electric lighting plant, ball bearings for gasoline locomotive friction drive, and ball bearings in bench milling machines. A revised price list and description of New Departure double-row, single-row, radax and magneto type ball bearings has been issued.

Foxboro Co., Foxboro, Mass. Bulletin 104, illustrating and describing the Foxboro line of indicating and recording thermometers. The bulletin describes clearly the actuating principles and the many marked improvements which have been embodied in the design. Information has been given and arranged in such a way as to make it easy for the prospective customer to pick out a thermometer that will exactly meet his requirements.

Hauck Mfg. Co., 140 Livingston St., Brooklyn, N. Y. Bulletin 69, showing foundry burners for cupola lighting, ladle heating and skin-drying molds. Several new features have been incorporated in the Hauck compressed air and hand pump burners for foundry service, which are illustrated and described in this bulletin. A special foundry outfit equipped with interchangeable burners and nozzles is illustrated on page 7.

Austin Co., Cleveland, Ohio. Bulletin illustrating examples of manufacturing buildings that have been erected by the Austin system in thirty to sixty days from the time of starting work. Standardized cross-sections and bay widths are employed, which means that the structural steel required can be held ready in fabricating plants, and all other materials held in stock or under order. This plan equalizes production and makes possible the erection of first-class buildings at low cost and in quick time.

Foote Bros. Gear & Machine Co., 210-220 N. Carpenter St., Chicago, Ill. General catalogue 12 of spur, bevel, miter, spiral, worm and internal gears, tractor gears, traction engine gears, heavy-duty hardened gears, rawhide pinions, and cut steel racks. The catalogue comprises 384 pages, 5½ by 8 inches, and is substantially bound. In addition to the price list of gears and machinery listed, a considerable amount of valuable technical information relating to gearing, the strength of gear teeth, etc., is included.

Hilliard Clutch & Machinery Co., Elmira, N. Y. Catalogue C of Hilliard friction clutches and friction cut-off couplings, illustrating and giving dimensions of the Hilliard line of clutches, including two of the latest developments—double disk clutches and ball bearing sleeve clutches. The ball bearing sleeve clutch illustrated is the Chapman ball bearing sleeve in combination with the Hilliard clutch mechanism. The company has, however, completed a standard design which will permit the use of any annular bearing in connection with the clutch sleeves.

Cutler-Hammer Mfg. Co., Milwaukee, Wis. Two-color, eight-page folder illustrating and describing Cutler-Hammer machine tool controllers, which was distributed to master mechanics and master car builders at the annual June convention at Atlantic City. The folder describes machine tool controllers in three classes, as plain starting, speed setting and speed regulating controllers. Five pages of the folder are devoted to large illustrations of Cutler-Hammer machine tool controllers installed on various machine tools, and one illustration shows one of several hundred controllers now in use in the new plant of the River Furnace Co. at Cleveland, Ohio.

Greenfield Tap & Die Corporation, Greenfield, Mass. Bulletin containing a detailed description of the Greenfield "gun" tap. The characteristics of this tap are shown by a severe test to which it was subjected by a user. The tool was used to tap a safe door made of five plates of steel welded together. Three of the plates were chrome-vanadium and two open-hearth steel. The company claims that from twenty-five to twenty-eight holes was the life when a high-speed steel tap was used on this job. A "gun" tap made of carbon steel tapped thirty-six holes before it was necessary to sharpen it. The book also contains tables giving sizes and prices of the "gun" taps in stock.

Link-Belt Co., Chicago, Ill., is issuing a book entitled "Personal Reminiscences of James Mapes Dodge," written by Charles Piez, president of the Link-Belt Co. The book contains an interesting account of the life of James Mapes Dodge, who had such an important part in American invention and engineering and in the development and success of the Link-Belt Co. The first part of the book deals with the development of the conveying and coal-storage business, in which Mr. Dodge took an active part. The second part of the book discusses Mr. Dodge's work in connection with the Taylor system of scientific management, and his wise adaptation of this system to the needs of the Link-Belt Co. Mr. Dodge's inventions in the power and transmission field are well known by all mechanical men.

S. K. F. Ball Bearing Co., Hartford, Conn. Booklet entitled "Better Electric Motors Equipped with S. K. F. Ball Bearings." This booklet, which is in the nature of a short treatise on the use of ball bearings in electric motors, is copiously illustrated and the matter is attractively arranged. It points out how the efficiency and the power factor of a motor are improved by the use of ball bearings because the air gap may be reduced without danger of the armature wearing down and being stripped by contact with the pole pieces. Some of the topics of special interest treated are "How Maintenance Charges are Reduced 66 per cent," "Motor Lengths Shortened 10 to 27 per cent," "A Discussion of Bearing Sizes," "Discussion of Gear Drive Motors," "Applications of Motors to Machine Tools," etc.

Lodge & Shipley Machine Tool Co., Cincinnati, Ohio. Catalogue of lathes, showing details of construction of threading and feed gearing, carriage, apron, tailstock, taper attachment, draw-in chuck and collets, relieving attachment, double-nose spindle, diameter stops, etc. The first general section is devoted to 14-inch, 16-inch, 18-inch, 20-inch, 22-inch, 24-inch, 27-inch, 30-inch, 36-inch, three-step cone double back-geared lathes, which are illustrated and specifications given. The selective head lathes are made in sizes of 16-inch, 18-inch, 20-inch, 22-inch, 24-inch, 27-inch, 36-inch, 42-inch and 48-inch swing. Examples of these are illustrated and data are given for all sizes. The catalogue includes examples of multiple diameter turned shafts, giving dimensions, material and time required to turn complete.

TRADE NOTES

Beaman & Smith Co., Providence, R. I., has completed a four-story reinforced concrete addition to its factory. This addition covers a floor space of 40 by 150 feet, and will be used for offices, drafting-room and pattern shop.

Abrasive Machine Tool Co., Providence, R. I., has built a factory in East Providence for the manufacture of grinding machines. The building is of reinforced concrete, one story high, 50 by 150 feet, with an L 20 by 30 feet, and is expected to be ready for occupancy October 1.

Link-Belt Co., Chicago, Ill., is enlarging its malleable foundry at Indianapolis to meet the increased demand for link-belt. The foundry extension will be one story high, 70 by 275 feet, with a wing 107 by 140 feet. It will house the company's fifth melting furnace and will provide space for sixty molders.

Grayson Tool Co., Indianapolis, Ind., has removed to its new factory at Charleston, W. Va. The factory is a modern shop, 200 by 175 feet, and will employ about 100 men. The firm will do contract work, make gages and manufacture and market the Grayson single, duplex and triplex full automatic surface grinders.

Diamond Power Specialty Co., Detroit, Mich., announces that its estimate of sales of "Diamond" soot blowers for the year beginning August 1, 1916, will be sufficient to equip 1,000,000 horsepower of boilers annually. The Diamond soot blowers are provided with insuluminum parts that are subjected to high temperature. This alloy has heat-resisting qualities far superior to iron and steel.

Prentiss Tool & Supply Co., 149 Broadway, New York City, dealer in machine tools and metal-working machinery, has been incorporated under the name of Henry Prentiss & Co., Inc. The new corporation will succeed to the business and properties of the old, but, with the exception of the name, there will be no change, the officers, directors, general organization and business policy remaining the same as heretofore.

Transmission Ball Bearing Co., 32 Wells St., Buffalo, N. Y., has found it necessary, owing to the rapidly increasing demand for Chapman ball bearings, to build and equip a factory having a capacity of three or four times the present output. The company is now in the market for machinery and equipment to handle a complete line of shafting bearings and loose pulley bushings, as well as machinery for manufacturing the "Universal" elevating truck.

Wismach & Co., 1513 Richard St., Milwaukee, Wis., are making rectangular gage standards such as have formerly been imported exclusively. These gage standards are hardened by a special process, and their measuring surfaces are distanced as indicated on each gage, within limits of 0.00001 inch. They are made in standard sets, but they are also furnished in sets of any desirable combination, varying by fractions of inches as well as of millimeters.

R. Martens & Co., Inc., 24 State St., New York City, announces that the original purpose of limiting its operations to the mechanical lines of industry will be strictly adhered to, but in order to conserve the enormous opportunity for non-mechanical lines, it has created a subsidiary company under the name of Russia Trade Corporation of America. The new concern will have a complete business organization, and its general offices will be in the Maritime Bldg., 8-10 Bridge St., New York City.

Hyatt Roller Bearing Co., Newark, N. J., has given the name of industrial department to its commercial sales division located in Newark with the factory. The company feels that the time is rapidly approaching when the industrial world will appreciate the economy of anti-friction bearings, as have the automobile builders. For that reason, the industrial department will be prepared to meet conditions and advise regarding the use of anti-friction bearings for lineshaft boxes, industrial trucks, mine cars, machine tools, electric motors, cement machinery, cranes and trolleys, textile machinery, blowers, fans and conveyors, etc.

Ph. Van Ommeren Corporation, 42 Broadway, New York City, has recently entered the New York shipping field as a branch of the business of the old Dutch shipping house of Ph. Van Ommeren, which was established in Rotterdam, Holland, nearly a century ago, and which now has branches all over the world. The American branch is incorporated under the laws of the state of New York, and the management will be in the hands of William H. Scholz, who for the past two years has been attached to the American legation at the Hague, acting as commercial adviser. The New York office is fully equipped for handling shipments to all parts of the world.

Philadelphia Brass Co., 917 Crozer Bldg., Philadelphia, Pa., has been incorporated with a capital of $101,000 for the manufacture of brass rods, extruded shapes and seamless tubes. The company has purchased a seventeen-acre tract at Downingtown, Pa., near Philadelphia, on which the plant will be erected, and it will start on day and night shifts to fill orders on hand as soon as erected. The directors are: C. C. Anthony, Lewis Burnham, Henry T. Coates, Jr., J. Lloyd Coates, Carl B. Ely, E. B. McCarthy and Walter S. Johnston; and the officers are: Henry T. Coates, Jr., president; William E. Chickering, secretary and treasurer; Walter S. Johnston, general sales manager.

CLASSIFIED AND WANT ADVERTISEMENTS

Will be found on page 285 of this issue and will be run in the same relative position in future.